Gerhard Wörner, Stefan Möller-McNett (Eds.)

International Lateinamerika-Kolloquium 2009

Abstracts and Program

Göttingen, April 7–9, 2009



Universitätsdrucke Göttingen

Gerhard Wörner, Stefan Möller-McNett (Eds.)
International Lateinamerika-Kolloquium 2009

erschienen in der Reihe der Universitätsdrucke
im Universitätsverlag Göttingen 2009

Gerhard Wörner, Stefan Möller-McNett (Eds.)

International Lateinamerika-Kolloquium 2009

Abstracts and Program

Geowissenschaftliches Zentrum
der Universität Göttingen,
April 7-9, 2009

Universitätsverlag Göttingen
2009

Bibliographische Information der Deutschen Nationalbibliothek

Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliographie; detaillierte bibliographische Daten sind im Internet über <http://dnb.ddb.de> abrufbar.

Herausgeber
Prof. Dr. Gerhard Wörner
Geowissenschaftliches Zentrum der
Universität Göttingen
Goldschmidtstraße 1-3
37077 Göttingen
http://www.uni-geochem.gwdg.de/

Abstract collection and layout: Stefan Möller-McNett
Coverimage: salt lake in Atacama desert, Chile. Image by Gerhard Wörner
Cover design: Margo Bargheer

http://univerlag.uni-goettingen.de
ISBN: 978-3-940344-77-9

Contents

1. Welcome and Acknowledgements

We welcome you to LAK-2009 at the GZG (Geowissenschaftliches Zentrum) of the Georg August Universität Göttingen
The DFG working group for geosciences in Latin America (AG Geowissenschaftliche Forschung in Lateinamerika) is organizing this meeting in order to bring together researchers from all fields of earth sciences and present an attractive program on the geological evolution of the South American continent and its margins, processes of mountain building, uplift and erosion as well as interaction between tectonic and climatic parameters. We also invite contributions from topics such as landscape evolution, ecology, natural resources, geo-hazards and economic geology.
For details on the DFG working group see: http://www.lag-dfg.de/ .

We are thankful to the German Research Foundation (Deutsche Forschungsgemeinschaft) for providing funds to support the organisation as well as travel and subsistence for almost 40 participants from Latin American countries. Additional funds were made available by the "Universitätsbund" of the University Göttingen, which is gratefully acknowledged.

We wish you all a successful meeting and a memorable time in Göttingen.

Göttingen, 6. April, 2009



Gerhard Wörner
(local LAK-Organiser)

2. Conference Information

Welcome Reception: An Ice-breaker Party is scheduled for the evening of April 6, starting at 18:00. Here you can meet old and new friends and also register for the meeting. You will be provided with your conference bag, which includes this abstract and program volume, name badge, your lunch- and dinner tickets (if you have opted and paid for this), as well as your receipt of conference fee payment and general information (e.g. map) on Göttingen.

Transportation within Göttingen: Your name badge will serve as a ticket for local bus transportation, which will be free of charge for conference participants. Please make sure you are carrying your badge with you when using the bus between your hotel and the conference site.

For *lunch* we recommend the University Cafeteria (called "Mensa"), which is within ten minutes of walking distance of the conference site; please follow the signs or ask any of the organisers.

The *Conference Dinner* will be held at the historic Klausenhof near the old castle of Hanstein. For those who have registered for the Conference Dinner, there will be a bus for you waiting outside the building, Wednesday April 8, which will leave at 17:30. Please be there on time, the bus will not wait.

For those of you who will receive *travel support*:
Please present your airline ticket and your passport at the conference office. We will hand out your travel support to you when you register.

There will be oral and poster session (see program). The poster session will take most of the second part of the afternoons and there will be free drinks until 18:30. Authors should be attending their posters at their sessions and times indicated in the program.

For orals sessions, please make sure you submit your Powerpoint presentation to the session chair until 20 minutes before the start of your session (not 15 minutes before your talk !)

3. Program (O = oral, P = poster, K = Keynote presentation)

Tuesday, April 7, 2009		**8:30-8:40**	**No**	**Opening Reception**
S-1 Morning Session April 7, 2009				**Reconstructing Orogenic evolution from sedimentary and metamophic records**
Bahlburg H	K	8:40-9:10	S1-K-1	Exploring the initiation of subduction and the coeval evolution of sedimentary basins- examples from the Phanerozoic Andean margin
Hauser N, Matteini M, Pimentel MM, Omarini R	O	9:10-9:30	S1-2	Combined U-Pb and Hf-isotope study on the Puncoviscana Formation in Tastil area, Eastern Cordillera, NW Argentina: Evidence for the maximum and minimum age
Augustsson C, Kocabayoğlu M, Chmiel H	O	9:30-9:50	S1-3	Provenance from cathodolouminescence colour spectra of detrital quartz in the Cambrian Mesón Group, NW Argentina
Reimann CR, Bahlburg H, Kooijman E, Berndt J, Gerdes A, Carlotto V	O	9:50-10:10	S1-4	Provenance of Ordovician and Devonian sandstones from southern Peru and northern Bolivia - U-Pb and Lu-Hf isotope evidence of detrital zircons and its implications for the geodynamic evo-lution of the Western Gondwana margin (14°-17°S)
Miller H, Adams Ch	O	10:10-10:30	S1-5	Erosion history of the southern Brazilian Shield as seen from detrital zircon U-Pb age patterns of sedimentary rocks of northwest Argentina.
Adams CJ, Miller H, Aceñolaza FG, Toselli AJ	O	10:30-10:50	S1-6	Detrital zircon U-Pb ages of the Puncoviscana Formation and its metamorphic equivalents in Catamarca and La Rioja, northwest Argentina
Coffee Break				**10:50-11:10**
S-2 Morning Session April 7, 2009		**Time**	**No**	**Paleoclimatic reconstructions and geomorphological evolution of the Andes and Amazon lowlands**
Hooghiemstra H, Vriend M, Groot MHM, Bogotá-Angel RG, Van der Plicht J, Lourens L, Berrio JC, and other Fúquene Project members	K	11:10-11:40	S2-K-7	Climate change and basin dynamics at 50-yr resolution during 2 glacial cycles (284-27 ka): a new record from Lake Fúquene
Hooghiemstra H, Moscol Olivera M, Bakker J, Cleef AM, Duivenvoorden JF	O	11:40-12:00	S2-8	Altitudinal forest line shifts, climate change, and land-use impact in northern Ecuador during the last three millennia: implications for Kyoto-protocol driven carbon sequestration projects
Glasmacher UA, Hackspacher P, Förster A, Franco AOB, Doranti C, Godoy D, Karl MP	O	12:00-12:20	S2-9	Long-term landscape evolution at the Western South Atlantic passive continental margin, Brazil
Lunch Break				**12:20-13:20**

S-2 Afternoon-Session April 7, 2009		**Time**	**No**	**Paleoclimatic reconstructions and geomorphological evolution of the Andes and Amazon lowlands**
Schittek K, Flores F, Torres G, Lupo L	O	13:20-13:40	S2-10	Altiplano peatlands in NW Argentina as archives for palaeoclimate research – potential, challenges and limitations
Karátson D, Telbisz T, Wörner G	O	13:40-14:00	S2-11	Volcano reconstruction and erosion rate calculation on stratovolcanoes and ignimbrite surfaces in the Central Andes
Breuer S, Kilian R, Baeza O, Arz H	O	14:00-14:20	S2-12	Interpretation of parametric echo sounding profiles in fjords of the Magellan Region (53°S), Chile
Decou A, Mamani M, Eynatten Hv , Wörner G	O	14:20-14:40	S2-13	Geochemical and thermochronological signals in Tertiary to Recent sediments from the Western Andes (15-19°S): proxies for sediment provenance and Andean uplift.
Richter A, Hormaechea JL, Dietrich R, DelCogliano D, Mendoza L, Connon G, Perdomo R, Fritsche M, Guerrero R	O	14:40-15:00	S2-14	Ocean tides and sea-level changes derived from tide gauge measurements in the Beagle Channel, Tierra del Fuego
Trombotto Liaudat D	O	15:00-15:20	S2-15	Classification of Andean permafrost, an attempt
Schimpf D, Kilian R, Mangini A, Kronz A, Spötl C	O	15:20-15:40	S2-16	The paleoclimatic significance of chemical, isotopic and detrital proxies in different high-resolution stalagmite records from the superhumid southernmost Chilean Andes (53°S)
Coffee Break				**15:40-16:00**
S-1 April 7, 2009 Afternoon Poster Session		**16:00-18:30**	**No**	**Reconstructing Orogenic evolution from sedimentary and metamophic records (Posters)**
Bahlburg H, Vervoort JD, Du Frane SA	P	15:40-18:30	S1-P-17	Timing of crust formation and recycling in accretionary orogens: The detrital zircon U-Pb and Hf, and the whole-rock Nd isotope evidence of Devonian to Permian turbidite deposits of the Gondwana margin in northern Chile
Chernicoff CJ, Zappettini EO, Santos JOS, McNaughton NJ	P	15:40-18:30	S1-P-18	The southernmost segment of the suture between Pampia terrane and the Rio de la Plata craton, La Pampa province, Argentina: constraints from zircon U-Pb SHRIMP dating and Hf isotopic data
Collo G, Astini RA	P	15:40-18:30	S1-P-19	Implications of detrital isotopic data from Cambro-Ordovician metasediments of the Famatina belt (Central Andes) in the Late Neoproterozoic-Early Paleozoic evolution of Western Gondwana
Di Cunzolo S, Pimentel M	P	15:40-18:30	S1-P-20	U-Pb La-ICP-MS geochronology of detrital zircons from Lower Palaeozoic rocks of the Eastern Cordillera, NW Argentina: Tectonic significance for the evolution of Western Gondwana
Drobe M, López de Luchi M, Steenken A, Frei R, Naumann R, Siegesmund S, Wemmer K	P	15:40-18:30	S1-P-21	Provenance of the Late Proterozoic to Early Cambrian metaclastic sediments of the Sierra de San Luis (Eastern Sierras Pampeanas) and the Cordillera Oriental, Argentina

Heberer B, Behrmann JH, Rahn M	P	15:40-18:30	S1-P-22	From sink to source – Inferring onland geodynamics and sedimentary pathways from the marine and estuarine record – A detrital apatite fission track study from the Chile continental margin (29-47°S)
Rehrmann S, Augustsson C	P	16:00-18:30	S1-P-23	Provenance of K/P sandstones from NE-Mexico
Rüsing T, Augustsson C, Büld M, Kooijman E, Berndt J, Zimmermann U	P	15:40-18:30	S1-P-24	Detrital zircons as provenance indicators in early Palaeozoic siliciclastic sandstones in NW Argentina
S-2 April 7, 2009 Afternoon Poster Session		**15:40-18:30**	**No**	**Paleoclimatic reconstructions and geomorphological evolution of the Andes and Amazon lowlands (Posters)**
Alves LSR , Guerra-Sommer M	P	15:40-18:30	S2-P-25	Paleoclimate analysis and growth rings of fossil woods in the Serra Alta Formation (Upper Permian), Paraná Basin, southern Brazil
Behling H	P	15:40-18:30	S2-P-26	Late Quaternary pollen records and their importance for Global Change research - Examples from tropical South America
Breuer S , Kilian R, Baeza O, Lamy, F	P	15:40-18:30	S2-P-27	Estimation of Holocene denudation rates for non-glaciated areas of the super humid southernmost Andes (53°S), Chile
Francois JP	P	15:40-18:30	S2-P-28	Are the North Patagonia islands the key areas to test the Darwin's glacial hypothesis?
Hermanowski B, Behling H, Lima da Costa M	P	15:40-18:30	S2-P-29	Late Quaternary environmental dynamics of Amazonian rainforest in northern Brazil – New palynological insights
Iturrizaga I	P	15:40-18:30	S2-P-30	The formation of talus cones and scree slopes as result of the paraglacial landscape transformation in the Aconcagua-Massif (Argentina) and the Marmolejo Massif (Chile)
Jasper A, Uhl D, Machado NTG, Gonçalves CV, Guerra-Sommer M, Cazzulo-Klepzig M	P	15:40-18:30	S2-P-31	Late Paleozoic wildfires in the South American part of the Gondwana Realm.
Koutsoukos EAM	P	15:40-18:30	S2-P-32	Paleobathymetric changes and paleoenvironmental turnover across the Cretaceous-Paleogene in Brazil
Lima G L, Oliveira MAT, Bauermann SG	P	15:40-18:30	S2-P-33	The Palynologic and Stratigraphic Characterization of the Alluvial Depositis, Campo do Ciama, São Bonifácio Municipality, Santa Catarina, Brazil*
Parica C	P	15:40-18:30	S2-P-34	δ18O and δ2H in Antarctic water precipitations. A discussion about tendencies.
Parica C, Remesal MB, Salani FM, Rinaldi CA	P	15:40-18:30	S2-P-35	Destroying a myth: Non drinkable water in Antarctic Stations
Parica C	P	15:40-18:30	S2-P-36	The iceberg A22A. The evolution of δ2H and δ18O in the upper levels and drifting in the Weddell Sea after the break-up.
Rondanelli M, Troncoso JM, León C	P	15:40-18:30	S2-P-37	Recent palynological studies in western Patagonia of Coyhaique region (45 ° S, 72 ° W), southern Chile
Schäbitz F and the PASADO-team	P	15:40-18:30	S2-P-38	First results from the ICDP deep drilling PASADO* project of maar Laguna Potrok Aike (Santa Cruz, Argentina)
Terrizzano C, Cortés JM	P	15:40-18:30	S2-P-39	Analysis of drainage anomalies as a tool to elucidate neotectonic soft-linked deformation zones.

S-4 April 7, 2009 Afternoon Poster Session		Time	No	Tectonics, Metamophic Processes and Basin Formation in Cordilleran Orogeny (Posters)
Del Cogliano D, Bagú D, Scheinert M, Dietrich R	P	15:40-18:30	S4-P-40	Methodology for the determination of a precise regional geoid model in Argentina
Contardo X, Kukowski N, Jensen A	P	15:40-18:30	S4-P-41	Mechanisms of marine forearc basin evolution along the accretive margin of south central Chile; insights from seismic data and analogue simulations
De la Cruz AA, Acosta-Pereira H, Aldana M	P	15:40-18:30	S4-P-42	New evidence of ammonites and its sedimentary context within Upper part of Chocolate Formation (Yura, Arequipa)
Ezpeleta M, Astini RA	P	15:40-18:30	S4-P-43	The Late Devonian glaciation in western Argentina: expanding the frontiers of Gondwanan glacial epoch
Ezpeleta M, Astini RA, Dávila FM, Cawood P	P	15:40-18:30	S4-P-44	SHRIMP U-Pb dating and subsidence analysis of pre-Andean Paganzo Basin, northwestern Argentina: Implications for late Paleozoic tectonic evolution of western Gondwana.
García Morabito E, Ramos VA	P	15:40-18:30	S4-P-45	Structure and tectonics of the inner retro-arc between 38º30' and 40ºS
Weinrebe W, Klaucke I, Voelker D, Bialas J, Behrmann J, Ranero CR, Diaz Naveas J, Geersen J	P	15:40-18:30	S4-P-46	Tectonics, fluid flow and slope stability of the central Chilean subduction zone revealed with multibeam bathymetry and deep-tow side-scan sonar surveys
Ghiglione MC, Yagupsky DL , Ghidella M, Ramos VA	P	15:40-18:30	S4-P-47	Eocene opening of Drake Passage: Geological and Geophysical evidence from Tierra del Fuego
Gomez ME, Richter A, Mendoza L	P	15:40-18:30	S4-P-48	Improvement of a local geoid model in Tierra del Fuego
Kapinos G, Montahaei M, Brasse H	P	15:40-18:30	S4-P-49	Magnetotelluric image of the South Chilean subduction zone
Larrovere M, Toselli A, Rossi J, de los Hoyos C, Basei M, Belmar M	P	15:40-18:30	S4-P-50	Age and P-T metamorphic conditions of the migmatitic basement of the Northwestern Sierras Pampeanas, Argentina.
Martínez Dopico CI, López de Luchi MG, Rapalini AE	P	15:40-18:30	S4-P-51	Distinguishing crustal segments in the North Patagonian Massif, Patagonia
Mendoza L, Dietrich R, Perdomo R, Hormaechea JL, Del Cogliano D, Fritsche M, Richter A	P	15:40-18:30	S4-P-52	Strain analysis of geodetic observation data in the Magallanes-Fagnano fault zone, Tierra del Fuego
Morón S, Montes C, Jaramillo C, Bayona G, Sánchez C	P	15:40-18:30	S4-P-53	Spectral analysis of geophysical logs from the Cerrejon Formation, Colombia.
Rabbia O, Demichelis A, Otamendi J, Tibaldi A	P	15:40-18:30	S4-P-54	New U-Pb zircon ages and Nd-Sr isopotic data for igneous and metamorphic rocks from northern Sierra de Comechingones, Argentina
Rabbia O, Galdames C, Alfaro G, Hernández L, Miller H	P	15:40-18:30	S4-P-55	Platinum group elements in ultramafic rocks from the central-south of Chile
Ramírez-Fernández JA, Torres-Sánchez SA, Cossío-Torres T	P	15:40-18:30	S4-P-56	Paleozoic Granjeno Schist and its implications in the evolution of the basement of the Sierra Madre Oriental, NE Mexico

Reich S, Nielsen SN	P	15:40-18:30	S4-P-57	Sedimentological and paleontological overview over the coastline of Mocha Island (south-central Chile)
Rojas Vera E, Folguera A, Zamora Valcarce G, Gímenez M, Ruiz F, Martínez P, Bottesi G, Ramos V A	P	15:40-18:30	S4-P-58	Structure at the retroarc zone between 37º and 39ºS based on gravimetric, magnetometric, seismic and field constraints: The Loncopué trough
Salani FM, Remesal MB, Parica CA, Cerredo ME	P	15:40-18:30	S4-P-59	The Marifil Formation in Northeastern Patagonia, Argentina
Salazar C, Stinnesbeck W, Quinzio-Sinn LA	P	15:40-18:30	S4-P-60	Biostratigraphy and paleobiogeography of Maastrichtian ammonites from Quiriquina Formation, Chile.
Salazar P, Kummerow J, Wigger P, Moser D, Asch G, Shapiro SA	P	15:40-18:30	S4-P-61	The recent stress field in the Precordillera of Northern Chile constrained from upper crustal microseismicity
Seibertz E, Spaeth C	P	15:40-18:30	S4-P-62	Belemnites in shallow water carbonates of the Sierra de La Silla (Lower Cretaceous, Nuevo León, NE Mexico)
Silva C, Bayona G , Channell JET	P	15:40-18:30	S4-P-63	Block rotations and its tectonic implications in the Isthmus of Panama: new paleomagnetic data of several structural domains in Panama, Central America
Bayona G, Jiménez G, Silva C	P	15:40-18:30	S4-P-64	An assessment to block rotation in northern South America: new paleomagnetic data of the Santa Marta massif, northern Colombia.
Vennari, VV	P	15:40-18:30	S4-P-65	Upper Jurassic-Lower Cretaceous Ammonoids of the Vaca Muerta Formation, Neuquén Basin, Argentina
Azevedo-Soares, HLC de	P	15:40-18:30	S4-P-66	Silurian Glaciation in the Amazon Basin and Chitinozoans (Trombetas Group) II
Groß K, Buske S, Shapiro SA, Wigger P	P	15:40-18:30	S4-P-67	Reflection seismic imaging of the Chilean subduction zone around the 1960 Valdivia Earthquake hypocenter

Wednesday, April 8, 2009

S-3 Morning Session April 8, 2009		**Time**	**No**	**Geological History and Paleontology**
Nielsen SN	K	8:30-9:00	S3-K-68	Cenozoic marine invertebrates of Chile: state of the art exemplified by mollusks
De la Cruz AA, Acosta Pereira H	O	9:00-9:20	S3-69	Sedimentary facies and ammonites relations between Arequipa and Tacna during Lower to Middle Jurassic
CarlottoV, Cardenas J, Cano V, Rodriguez R	O	9:20-9:40	S3-70	Paleogeographic boundary in the evolution of the Pucara Basin (Triassic-Liassic) and the Arequipa basin (Lias-Dogger): an inheritance of the block accreted during the Mesoproterozoic
Stinnesbeck W, Pardo Pérez J, Salazar Soto C, Leppe Cartes M, Frey E	O	9:40-10:00	S3-71	A new fossil lagerstätte for ichthyosaurs of early Cretaceous age in the Torres del Paine National Park, Southernmost Chile
Pardo Pérez J, Stinnesbeck W, Salazar Soto C, Leppe Cartes M, Frey E	O	10:00-10:20	S3-72	Ichthyosaurs from Torres del Paine National Park, Southernmost Chile
Coffee Break				**10:20-10:40**

S-4 Morning Session April 8, 2009		**Time**	**No**	**Tectonics, Metamophic Processes and Basin Formation in Cordilleran Orogeny**
Pindell J	K	10:40-11:10	S4-K-73	Mantle reference frame and generation of detached- and flat-slab subduction geometries in Caribbean evolution
Garza-Rocha D, Rabbel W, González-Roque AA, Vásquez-García M	O	11:10-11:30	S4-74	Processing of 4C-2D OBC reflection seismic data from the southern Gulf of Mexico (Oil Field Cantarell)
Hernández-Treviño T, Solis-Pichardo G, Schaaf P, Pérez Gutiérrez R, Torres de León R, Salgado Soto Z, Meza García VB	O	11:30-11:50	S4-75	Significado y alcances estratigráficos de deformación post-Laramídica en la región de Acapulco, Tierra Colorada y Chilapancingo: Estado de Guerrero Región Sur de México.
Brasse H, Kapinos G, Alvarado GE, Muñoz A, Worzewski T	O	11:50-12:10	S4-76	First results of a magnetotelluric study in the Central American Isthmus
Maresch WV, Kluge R, Baumann A, Pindell J, Krückhans-Lueder G, Stanek KP	O	12:10-12:30	S4-77	Early Caribbean-South American interaction: The evidence from Margarita Island, Venezuela
Lunch Break				**12:30-13:30**
Lücke OH, Götze H-J, Alvarado GE, Schmidt S, Fairhead D	O	13:30-13:50	S4-78	Constrained 3D density model of the upper crust from gravity data interpretation for the Central Volcanic Range of Costa Rica: fluid and volatile pathways and reservoirs for the southeastern end of the Quaternary Central American Volcanic Arc.
Morón S, Montes C, Cardona A, Valencia V, Farris D, Rodriguez I, Jaramllo C	O	13:50-14:10	S4-79	Miocene Cucaracha Formation in Panama, climatic or tectonic event?
Massonne H-J, Toulkeridis T	O	14:10-14:30	S4-80	High-pressure, medium-temperature metamorphic rocks in the Ecuadorian Cordillera Real - Evidence for continental collision
Sempere T, Demouy S, Benoit M, García F, Jacay J, Rousse S, Saint-Blanquat MD	K	14:30-15:00	S4-81	The birth of the Andes: Abrupt onset of rapid arc growth ~91 Ma ago
Espinoza F, Cornejo P, Matthews S	O	15:00-15:20	S4-82	Geochronology of Late Cretaceous-Early Cenozoic magmatism in Northern Chile (24º30'–26º S)
Willner AP, Massonne H-J, Gerdes A , Hervé F, Sudo M, Thomson S	O	15:20-15:40	S4-83	Does Chilenia exist? Evidence from the evolution of collisional and coastal accretionary systems between the latitudes 30°S and 35°S
Hervé F, Calderón M, Fanning M, Kraus S, Pankhurst RJ, Mpodozis C, Klepeis K, Thomson S	O	15:40-16:00	S4-84	The age, nature and significance of the basement rocks of the Magallanes basin and of Cordillera Darwin, Tierra del Fuego, Chile: a SHRIMP U-Pb study of igneous and detrital zircons.
Folguera A, Rojas Vera E, Spagnuolo M, García Morabito E, Orts D, Bottesi G, Ramos VA	O	16:00-16:20	S4-85	Tectonic evolution of the southern, central and northern Patagonian Andes (34º30´- 43º30´S)
Open Posters April 8, 2009				**16:20-17:30 All Sessions, Coffee, Beers**
Conference Dinner April 8, 2009		**17:30-23:00**		**Burg Hanstein and Klausenhof**

Thursday, April 9, 2009				
S-5 Morning Session April 9, 2009		**Time**	**No**	**Environmental Issues in Latin America**
Yutsis VV, Levchenko OV., Lowag J, Krivosheya K, de León Gómez H, Kotsarenko A	K	8:30-9:00	S5-K-86	Bottom topography, recent sedimentation and water balance of Cerro Prieto Dam, NE Mexico
Mathis A, Peregovich B, de Azevedo Mathis A	O	9:00-9:20	S5-87	A sustentabilida de da mineração na Amazônia – o caso do Estado do Pará (Brasil)
Wolff E	O	9:20-9:40	S5-88	Transferencia colombiana de conocimientos y experiencias de producción limpia en el beneficio de minerales auro-argentíferos.
S-6 Morning Session April 9, 2009		**Time**	**No**	**Hazards and Hazard Migitation**
Moreiras MS	K	9:40-10:10	S6-89	Inferences of Late Pliocene-Pleistocene rock avalanches clustering in the Central Andes (32º LS).
Strauch W, <u>Castellón A</u>	O	10:10-10:30	S6-90	Contribution to Early Warning on landslides in Central America using precipitation estimates from meteorological satellite data in real time
León X, Bautista M, Strauch W	O	10:30-10:50	S6-91	First experience with a national GIS on georisks in Guatemala
Coffee Break				**10:50-11:10**
Menjívar L, Reyes M, Alvarado L, Ramos A	O	11:10-11:30	S6-92	Estimación de la intensidad macrosísma para El Salvador y su incorporación al Sistema de Información Geográfica.
Protti M, V González V, Psencik K, Dixon T, Schwartz S, LaFemina P, Kato T, Melborne T	O	11:30-11:50	S6-93	Slow earthquakes on the Nicoya, Costa Rica, seismic gap
Piepenbreier J, <u>Spiske M,</u> Benavente C, Steffahn J, Bahlburg H	O	11:50-12:10	S6-94	Sedimentological aspects of recent and historical tsunami events along the coast of Peru
López A, Müller B, Heidbach O	O	12:10-12:30	S6-95	Unravelling of the modern stress field, coulomb stress changes and seismic risk in Costa Rica, an applied approach.
Lunch Break				**12:30-13:30**
S-7 Afternoon Session April 9, 2009		**Time**	**No**	**Ore deposits**
Pons MJ, Franchini MB, Giusiano A, Licitra DT	O	13:30-13:50	S7-96	The copper and bitumen mineralization in Barda Gonzáles and Tordillos prospects, Nequén, Argentina
Sosa G, Van den Kerkhof AM, Urbina N, Gallard C	O	13:50-14:10	S7-97	Fluid inclusions and cathodoluminescence of hydrothermal breccias from the La Carolina volcanic field, San Luis, Argentina: Implications for the genesis of ore mineralization in epithermal systems
Arévalo C, Creixell C	O	14:10-14:30	S7-98	The Atacama Fault System and its role on the migration and deposition of iron oxide copper gold and magnetite-apatite ores: an evaluation from the Los Choros and Huasco valleys

S-8 Afternoon Session April 9, 2009		**Time**	**No**	**Magmatic Processes in Cordilleran Orogeny**
Sumita M, Schmincke H-U	K	14:30-15:00	S8-K-99	The explosive phases of Jorullo Volcano, the first historic eruption in Mexico
Schaaf P, Bandy W, Mortera C, Michaud F, Ruffet G	O	15:10-15:30	S8-100	Mid Ocean Ridge Basalts from the Pacific Rivera Plate, Mexico: Heterogeneous geochemistry and geochronology.
Velasco-Tapia F, Chávez-Cabello G, Martínez-Limas NA, Gómez-Alejandro AG, Becerra-González C, Medina-Barrera F	O	15:30-15:50	S8-101	Mineralogy and geochemistry of Upper Cretaceous volcanic ash- layers of the NE Mexico: San Felipe Formation
Villanueva Lascurain D, Schaaf P, Solís Pichardo G, Hernández Treviño T, Salazar Juárez J, Corona Chávez P	O	15:50-16:10	S8-102	Petrogenesis of gabbros from the Jilotlan pluton, Jalisco, Mexico.
Guzmán S, Petrinovic I, Seggiaro R	O	16:10-16:30	S8-103	Luingo (Pucarilla - Cerro Tipillas Volcanic Complex), the oldest caldera in the SE portion of the Central Andes?
Coffee Break				**16:30-16:50**
S-5 April 9, 2009 Afternoon Poster Session		**16:30-18:30**	**No**	**Environmental Issues in Latin America (Posters)**
Baade J, Hesse R	P	16:30-18:30	S5-P-104	Irrigation agriculture in the western coastal desert – an anthropogenic sediment trap
Baggio H, Horn AH	P	16:30-18:30	S5-P-105	Natural and anthropogenic concentration and distribution of heavy metals in superficial water and current sediment in the Formoso river basin, Buritizeiro Municipality - MG, Brazil
Baggio H, Horn AH, Rodet MJ, Rodet J, Trindade WM	P	16:30-18:30	S5-P-106	Some materials used in Buritizeiro archeological site-MG, Brazil and its possible regional origin.
Costa ML, Trindade A, Behling H, Hermanowski B	P	16:30-18:30	S5-P-107	Lake landscape on lateritic iron crust over high plateaus in the eastern Amazon
Fariña D, Morel A, Pasig R	P	16:30-18:30	S5-P-108	Plan der ordenamento terretorial del distrito de Paraguarí, República del Paraguay
Frausto-Martínez O, Ihl T, Giese S	P	16:30-18:30	S5-P-109	Identificación de la susceptibilidad a inundación en las formas exocarsticas del noreste de península de Yucatán, México.
Gursky HJ, Orozco G, Cervantes Y, Pierra A, Schwarzer A	P	16:30-18:30	S5-P-110	Moa Bay, eastern Cuba: Geoenvironmental characteristics and problems of a modern tropical lagoon – first results
Hartmann G, Mamani M, Wörner G	P	16:30-18:30	S5-P-111	Lead isotopic fingerprints of fauna and crustal isotope domains as a basis for tracing origin and migration of prehistoric people in the Central Andes
Horn AH Baggio H, Trindade WM, Braga LL	P	16:30-18:30	S5-P-112	Contamination by mineralogical dust emission of Si and Fe-Si industry in the region of Pirapora and Várzea da Palma, MG, Brazil: and its ambiental and health effects

Horn AH, Aranha PA, Baggio H, Palmares P, Trindade WM	P	16:30-18:30	S5-P-113	Preliminary interpretation of GPR-profiles executed on three selected Veredas in the Rio Formoso Sub basin of the São Francisco Basin, MG, Brazil.
Moraes AF de, Horn AH, Pereira AAG, Baggio H	P	16:30-18:30	S5-P-114	Avaliacao da vulnerabilidade quimica dos solos de area carstica de Minas Gerais - Brazil a contaminacao por cromo
Insfrán A, Houben G, Rojas C, Silvero J	P	16:30-18:30	S5-P-115	Manejo sostenible de lentes de agua dulce en el distrito de Benjamin Aceval, Chaco Paraguayo
Pinzón Ángel JM	P	16:30-18:30	S5-P-116	Mejoras del proceso de beneficio de minerales auroargentíferos del distrito minero Vetas-California (Santander-Colombia) para reducir la contaminación ambiental.
Kiel S, Nielsen SN	P	16:30-18:30	S5-P-117	Evolutionary history of the marine latitudinal diversity gradient along the Pacific coast of South America
Weiß H, Neder KD, Walde DH, Hirsch M, Roeser PA, Lohe C, Makeschin F	P	16:30-18:30	S5-P-118	Water resources in the future climate change scenario: Development of an integrated management concept for water supply in the Federal District of Brasília – DF (Central Brazil)
Oliveira JAS, Saturnino JO, Sousa OM, Moresi CMD, Souza JSB	P	16:30-18:30	S5-P-119	Mineral pigments from Minas Gerais – Brazil. Part III: Application to producing paints"
Dávila Pórcel RA, De León Gómez H, Velasco Tapia F, Hoppe A, Schüth C	P	16:30-18:30	S5-P-1201	Hydrogeology and Hydrochemistry of groundwater in the Pablillo River Basin Linares, Nuevo León, Mexico.
De la Cruz-Reyna S, Hernández C	P	16:30-18:30	S5-P-121	Contaminacion de aguas subterranes, Sub Cuenca Oriental del Acuífero de Managua: Determinación de zonas de captura para pozos de Bombeo.
Velasquez C	P	16:30-18:30	S5-P-122	Aquifer transboundary Patanal in Paraguay
S-6 April 9, 2009 Afternoon Poster Session		**Time**	**No**	**Hazards and Hazard Migitation (Posters)**
Anasetti A, Krastel S, Weinrebe X, Klaucke I, Bialas J	P	16:30-18:30	S6-P-123	The Valdes submarine landslide: a landward facing landslide off southern Chile
Acosta N, Strauch W, Castellón A, Larreynaga A, Funes G	P	16:30-18:30	S6-P-124	GIS based tsunami hazard mapping in Nicaragua, El Salvador and Honduras and application to disaster prevention measures
Strauch W, Muñoz A, Mayorga E, Castellón A, Acosta N, Montoya I, Rosales M	P	16:30-18:30	S6-P-125	GIS based natural hazard assessment for three zones proposed for the construction of a new refinery at the Pacific Coast of Nicaragua
Castellón A, Bonilla G, Acosta N, Meyrat S, Espinales E, Martínez O	P	16:30-18:30	S6-P-126	Spatial and temporary dynamics of land cover and land use in the natural reserve of Apoyo Lagoon, Nicaragua - 1972 to 2007
Strauch W, Muñoz A, Blanco M, Collado C, Castellón A, Acosta N	P	16:30-18:30	S6-P-127	Massive use of GIS for natural hazard assessment on 90 low-cost house building projects in Nicaragua
Silva E, Strauch W, Castellon A, Funes G	P	16:30-18:30	S6-P-128	Comprehensive geohazard assessment for Honduras and the development of a national GIS on georisks

Chapa-Guerrero JR, Chapa Arce R , García Puente DM, Lemus Alarcón OR, Garza Vela LA, Méndez DS, Ibarra Martínez SE	P	16:30-18:30	S6-P-129	Análisis geológico estructural para la determinación de riesgos geológicos en el sureste del área metropolitana de Monterrey (Cañón el Huajuco, La Estanzuela), Nuevo León, México
Feldhaus L, Castellón A, Palucho R, León X, Funes G, Strauch W	P	16:30-18:30	S6-P-130	Progress of the application of GIS on georisks in Central America
Mendoza-Rosas AT, De la Cruz-Reyna S	P	16:30-18:30	S6-P-131	A statistical method based on historical eruption data for volcanic hazard assessment: applications to active volcanoes.
Morales-Simfors N, Sivertun Å, Haraldson J	P	16:30-18:30	S6-P-132	Use of Geographical Information Systems (GIS) in analyzing volcanic gas emissions on the environment at Poás Volcano, Costa Rica
Spiske M, Böröcz Z, Bahlburg H	P	16:30-18:30	S6-P-133	The origin of coastal boulder deposits in the southern Caribbean: hurricane versus tsunami
Piepenbreier J, Spiske M, Benavente C, Steffahn J, Bahlburg H	P	16:30-18:30	S6-P-134	Sedimentological analysis of tsunami deposits along the coast of Peru
Pulgarín B, Cardona C, Santacoloma C, Trujillo , Bolaños R, Narváez A, Monsalve ML , Agudelo A, Calvache M, Manzo O	P	16:30-18:30	S6-P-135	Volcan Nevado de Huila (Colombia): Erupción y lahar del 20 de noviembre 2008
Kotsarenko A, Grimalsky V, Villegas Cerón RA, Koshevaya S, Yutsis V, Pérez Enríquez R, López Cruz-Abeyro JA, Valdés-Gonzáles C	P	16:30-18:30	S6-P-136	Anomalies in the variations of the radon concentration related to geodynamical processes in the volcano Popocatepetl, Mexico
S-7 April 9, 2009 Afternoon Poster Session		**Time**	**No**	**Ore deposits (Posters)**
Pérez W, Benítez JC, Medina M	P	16:30-18:30	S7-P-137	Paso Yobai epithermal gold - Paraguay
Martínez JC, Dristas JA, Massonne H-J, Theye T, van den Kerkhof AM	P	16:30-18:30	S7-P-138	Hydrothermal alteration patterns in Tandilia Ranges, Olavarría area, Argentina.
Lohmeier S, Lehmann B, Du A, Burgess R	P	16:30-18:30	S7-P-139	Geology and exploration geochemistry of the El Volcán Gold Project in the Maricunga Belt, northern Chile
Méndez-Delgado S, García-Peña Á , Medina-Ferrusquía EL	P	16:30-18:30	S7-P-140	Mediciones de susceptibilidad magnética con el equipo GMS-2 de Geoinstruments, Ltd. a escala de laboratorio
Peregovich B, Mathis A	P	16:30-18:30	S7-P-1412	50 Years TMP – Transition from small-scale artisanal gold mining to large-scale corporate mining in the Tapajós Mineral Province (TMP), Brazil – potential and needs
Rosas S, Muñoz C	P	16:30-18:30	S7-P-142	Sedimentological and geochemical characterization of the Paleozoic carbonate rock related to a Ni-Co ore showing at the Yauli Dome – Central Peru
Villarreal-Uribe AL, Méndez-Delgado S, Constante-Galván H, Garza-Rocha D	P	16:30-18:30	S7-P-143	Mediciones de gradiente de campo magnético en un Campo de Experimentación Geofísica en la Facultad de Ciencias de la Tierra, UANL, Méxic

S-8 April 9, 2009 Afternoon Poster Session		Time	No	Magmatic Processes in Cordilleran Orogeny (Posters)
Banaszak M, Wörner G, Botcharniko R, Holtz F, Hora J	P	16:30-18:30	S8-P-144	Distinct magma plumbing and storage systems inferred from mineral chemistry and geothermobarometry of four volcanic centres in the central Andes
Betancourt Devia JA,Tejada Avella ML, Guevara AN, Weber-Scharf M, Gómez Tapias J	P	16:30-18:30	S8-P-145	Tholeiitic and calc-alkaline volcanism associated to the active continental margin of the Miocene of Colombia
Botcharnikov RE, Bonecke C, Holtz F, Torresi G, Banaszak M, Wörner G	P	16:30-18:30	S8-P-146	Experimental constraints on differentiation and mixing processes in the evolution of Central Andean magma systems: Parinacota and Taapaca volcanoes
Brandes C, Winsemann J	P	16:30-18:30	S8-P-147	The Moín High, East Costa Rica: volcanic origin or contractional structure
Castro A, Fernández C, Moreno-Ventas I, Gallastegui G, Corretgé LG, Vujovich G, Martino R, Becchio R, Otamendi JE, Heredia N, Gerya T	P	16:30-18:30	S8-P-148	A multidisciplinary project on cordilleran batholiths in Argentina : New data and perspectives
De los Hoyos C, Willner AP, Larrovere M, Rossi J, Toselli A	P	16:30-18:30	S8-P-149	Thermobarometry and geochronology of metapelites and granitoids of the eastern Sierra de Velasco, Sierras Pampeanas, Argentina: P-T paths and exhumation rates during the Famatinian Cycle.
Diaz D, Brändlein D, Brasse H	P	16:30-18:30	S8-P-150	Magnetotelluric study of Parinacota and Lascar volcanoes
Dzierma Y, Thorwar, M, Rabbel W, Comte D, Legrand D, Bataille K, Iglesia P, Prezzi C	P	16:30-18:30	S8-P-151	Ongoing seismological investigations around Villarrica Volcano, Southern Chile
Salazar L, Kley J, Monaldi CR, Rossello EA	O	15:00-15:20	S8-P-152	Orogen-parallel shortening in the central Andes: examples from NW Argentina and the role of normal fault reactivation
Gilbert D, Freundt A, Kutterolf S	P	16:30-18:30	S8-P-153	Magmatic evolution of the two caldera-forming tephras of the Apoyo Caldera / Nicaragua
Mamani M, Wörner G	P	16:30-18:30	S8-P-154	Tracing the source of Neogene ignimbrites in the Western Andean by isotope provenance.
Martínez JC, Dristas JA, Massonne H-J, Theye T	P	16:30-18:30	S8-P-155	Bulk-rock geochemistry of the meta-igneous rocks from the Tandilia Range, Argentina
Pérez W, Freundt A, Kutterolf S	P	16:30-18:30	S8-P-156	Characteristics of the phreatoplinian layers the Congo and Conacaste tephras (Coatepeque Caldera, El Salvador)
Pompa-Mera V, Schaaf P, Weber B , Solís-Pichardo G, Hernández-Treviño T, Ortega-Gutiérrez F	P	16:30-18:30	S8-P-157	Devonian and Ordovician Magmatism in the Maya Block: Chiapas Massif area, SE Mexico
Rausch J, Schmincke H-U	P	16:30-18:30	S8-P-158	Nejapa Tephra: The youngest (c. 1 ka BP) highly explosive hydroclastic basaltic eruption in western Managua (Nicaragua)

Salani FM, Remesal MB, Parica CA, Cerredo ME	P	16:30-18:30	S8-P-159	The basaltic volcanism of Pire Mahuida Complex, extraandean Patagonia, Argentina.
Salani FM, Remesal MB, Parica CA, Cerredo ME	P	16:30-18:30	S8-P-160	The Neogene Agua de la Piedra Volcanic Complex, Patagonia, Argentina
Sardi F, Grosse P, Murata M, Navas A	P	16:30-18:30	S8-P-161	Large-ion lithophile elements in K-feldspar as monitors of magmatic evolution in the Velasco Pegmatitic District, La Rioja province, Argentina
Solís Pichardo G, Martínez-Serrano R, García-Tovar G, Cadoux A	P	16:30-18:30	S8-P-162	Sr-Nd-Pb isotopic compositions of Iztaccíhuatl and Tláloc-Telapón volcanoes, Sierra Nevada, Mexico: Evidence for different magma generation processes.
Söllner F, Grosse P, Gerdes A, Toselli AJ, Rossi JN	P	16:30-18:30	S8-P-163	U-Pb LA-ICP-MS age determinations of growth impulses in zircons from Carboniferous post-orogenic granites, Sierra de Velasco (NW-Argentina).
Such P, Castro A, Aceñolaza FG	P	16:30-18:30	S8-P-164	Geochemistry of Ordovician volcanic domes of the Las Planchadas Fm, Famatina, System, Argentina.
Such P, Castro A	P	16:30-18:30	S8-P-165	REE and major elements analyses in volcanic lithoclasts of pyroclastic rocks with EDS and laser ablation (LA-ICP-MS) techniques. Planchadas Fm., Famatina System, Argentina.
Torresi G, Botcharnikov RE, Holtz F, Banaszak M, Wörner G	P	16:30-18:30	S8-P-166	Chemical, petrologic and experimental constraints on the pre-eruptive conditions of Lascar volcano, Central Andean magma systems
Valdez-Moreno G, Schaaf P, Kusakabe M	P	16:30-18:30	S8-P-167	Isotopic variations throughout Colima Volcanic Complex, México.
Vásquez P, Creixell C, Arévalo C	P	16:30-18:30	S8-P-168	Geochemical constraints on the Late Triassic plutonism along the Chilean margin: new data from the Carrizal Bajo Intrusive Complex and tectonic implications
Wegner W, Wörner G, Harmon RS, Jicha B	P	16:30-18:30	S8-P-169	Geochemical evolution of arc magmatism and building of the Central American land-bridge since the Late Cretaceous

4. **Abstracts** (in first author alphabetical order)

GIS based tsunami hazard mapping in Nicaragua, El Salvador and Honduras and application to disaster prevention measures

Acosta N 1, Strauch W 1, Castellón A 3, Larreynaga A 2, Funes G 4

1 Bundesanstalt für Geowissenschaften und Rohstoffe (BGR, Germany), Project on Mitigation of Georisks, Managua, Nicaragua, norwin.acosta@gf.ineter.gob.ni, wilfried.strauch@yahoo.com
2 Servicio Nacional de Estudios Territoriales (SNET), San Salvador, El Salvdor
3 Instituto Nicaragüense de Estudios Territoriales (INETER), Managua, Nicaragua
4 Comisión Permanente de Contingencias (COPECO), Tegucigalpa, Honduras

We report about initiatives on tsunami hazard mapping in Nicaragua, El Salvador and Honduras. The occurrence of 49 tsunamis is documented for Central America since the 16th century (Fernandez et al., 2000). Among them, the 1992 Tsunami on the Nicaraguan Pacific coast caused by an Mw=7.6 earthquake was the largest one causing disastrous destruction and the death of more than 170 people (Satake et al, 1993).

In Nicaragua tsunami hazard maps in 1:50,000 scale were elaborated, in 2004-2005, for all the Pacific coast of the country (SINAPRED, 2005) using the 5m and 10 m contour lines of the national topographic maps as part of a multi-hazard assessment for 30 municipalities in Western Nicaragua. Then in 2006, the 4 areas with the largest settlements on the Nicaraguan Pacific coast - Corinto, Puerto Sandino, Masachapa and San Juan del Sur - were selected for a more detailed study (JICA-INETER, 2006; Yamazaki et al., 2007). Each strip had an extension of about 30 km each along Pacific coast of Nicaragua. These maps are based on the observed worst historical tsunami inundation record, which is the one of 1992. It is assumed that future tsunami earthquakes with similar magnitude would occur again in these areas as the worst case. Based on numerical simulation "the worst case scenario" for each one of the four study areas was estimated moving the same dimension of the fault along the coast. The resulting maps in 1:50,000 scale have served as basic reference for the development of more detailed hazard and evacuation maps.

The first high resolution maps were developed by INETER in 2006-2007 for the Masachapa area (Acosta & Strauch, 2008) and could be used for tsunami disaster prevention measures by related Nicaraguan governmental institutions, local governments, and communities etc.. The maps on a 1:5,000 scale were elaborated using digital elevation models with 1 m spatial sampling. Hazard was classified schematically according the height above highest tide level: 0-2 m: high hazard, 2-5 m: medium, 5-10 m: low, 10-20 m: very low, more than 20 – safe area. In this pilot project participated the local municipality and local stakeholders, Ministry of Education, National Police, Nicaraguan Red Cross, Ministry of Health, Ministry of Tourism, Nicaraguan Geosciences Institute (INETER), National System for Disaster Preven-

tion (SINAPRED), Swiss Agency for Development and Cooperation (SDC). The following activities were carried out: 1) Development of a tsunami warning plan; 2) Installation of a seismic station and a sea gauge in Masachapa; Reception of tsunami warning from INETER via voice communication by radio; - Installation of a siren at each of the 4 population centers of the area 3) Investigation of awareness level and information needs for different population groups; 5) Evacuation drills (Strauch et al., 2007)

In 2008, similar maps were elaborated for El Astillero in the municipality of Tola (Acosta, 2008). A high resolution tsunami hazard mapping project was recently finished for the area of Corinto (Castellón, 2009). Another tsunami hazard mapping project is recently going on for the area of Puerto Sandino in preparation of a large industrial project for the development of a new refinery (Talavera, 2009). These three projects include also disaster prevention measures similar to those mentioned above for Masachapa.

The experiences made in Nicaragua were applied, in 2009, in an effort to generate high resolution tsunami hazard maps for the coastal strip of the Fonseca Gulf. This is a large bay of the Pacific Ocean, bounded northwest by El Salvador, northeast by Honduras, and southeast by Nicaragua. It reaches inland for approximately 65 km and covers an area of about 1,800 square km. Its entrance (32 km across) is marked by Cape Amapala in El Salvador and Cape Cosigüina in Nicaragua. The gulf widens to approximately 80 km. Among the 36 islands in the gulf the largest and populated ones are Zacate Grande, El Tigre, and Meanguera, all of volcanic origin. The main ports are the new harbor of Cutuco (La Unión) in El Salvador, Amapala in Honduras. The largest settlement in the Gulf is the municipality of La Unión (37,000 inhabitants).

Unique on the Pacific coast of the Americas – the tsunami hazard in the Fonseca Gulf is not only due to distant, regional and local earthquakes in the Pacific Ocean but sources of local tsunamis can also be volcanic eruptions, surges, submarine volcanic explosions, landslides or volcano collapse. Cosigüina volcano in Nicaragua (Scott et al. 2006) is known for a very large eruption in 1835 (Volcanic Explosivity Index (VEI)**:** 5), Conchagua volcano in El Salvador is actually dormant.

The tsunami hazard maps for Fonseca Gulf were elaborated in cooperation with local authorities, emergency commissions and geo-scientific institutions of the three countries, together with Bundesanstalt für Geowissenschaften und Rohstoffe (BGR Germany).

Tsunami hazard was delineated in a multi-hazard map (Abel et al., 2004) for the city of Managua, Nicaragua as the shores of Lake Managua can be affected by tsunamis generated by volcanic explosions or landslides related to the Apoyeque and Momotombo volcanic complexes (Freundt, et al, 2007). An overview map indicating coastal hazard due to tsunamis, seiches and meteorological phenomena in Lake Nicaragua was elaborated using the 30m DEM of Nicaragua (Strauch, 2004).

References

Abel Th., Álvarez A., Amador A., Blanco R., Chávez G., Devolí G., Guzmán C., Kuhn D., Schillinger St., Schmidt R., Strauch W., Toloczyki M., Traña M., Winkelmann L., Zambrana Z. (2004). Mapas de Georiesgos de Managua y sus Alrededores - Unpublished Reports and Maps, INETER-BGR, Managua, September 2004

Acosta N. (2008) Elaboración de mapas de amenaza de tsunami para El Astillero, Municipio de Tola, INETER, unpublished report

Acosta N. & Strauch W. (2008). Mapas de Amenaza, de Rutas de Evacuación y Zonas de Concentración en caso de Tsunami para varios poblados en la Costa del Pacífico de Nicaragua Abstract in Spanish, Geological Congress of Central America, San José, Costa Rica, July 02-05, 2008

Castellón A. (2009) Elaboración de mapas de amenaza de tsunami para Corinto, INETER, unpublished report

Fernandez M., Molina E., Havskov J. and Atakan K. (2000) Tsunamis and Tsunami Hazards in Central America, in: Natural HazardsVolume 22, No 2

Freundt A., Strauch W., Kutterolf St. And Schmincke H.-U. (2007). Volcanogenic Tsunamis in Lakes: Examples from Nicaragua and General Implications, Pure and Applied Geophysics, Volume 164, Numbers 2-3 / marzo de 2007

JICA-INETER (2006) "The Study for Establishment of Base Maps for GIS in the Republic of Nicaragua", unpublished report, Japan International Cooperation Agency (JICA) and INETER, Managua, Nicaragua

Satake, K.; Abe, Ka.; Abe, Ku.; Bourgeois, J.; Estrada, F.; Iio, Y.; Imamura, F.; Katao, H.; Noguera, E.; Tsuji, Y. (1993) Tsunami field survey of the 1992 Nicaragua earthquake, Eos, Transactions American Geophysical Union, Volume 74, Issue 13, p. 145-145

Scott W., Gardner C., Devoli G., and Alvarez A. (2006) The A.D. 1835 eruption of Volcán Cosigüina, Nicaragua: A guide for assessing local volcanic hazards, in: GSA Special Paper 412: Volcanic Hazards in Central, America. 167–187

SINAPRED (2005) Proyecto de Reducción de la Vulnerabilidad ante Desastres Naturales, Componente D2A - Análisis de Riesgos e Incorporación de la Gestión Preventiva en la Planificación Municipal, desarrollado por la Secretaría Ejecutiva del Sistema Nacional para la Prevención, Mitigación y Atención de Desastres (SE-SINAPRED), Managua 2005, http://www.ineter.gob.ni/geofisica/proyectos/30municipios/index.html

Strauch W. (2004) Mapa de amenaza de tsunami para Nicaragua basado en el DEM de 30m, INETER, Managua, Nicaragua, unpublished report

Strauch, W., Talavera, E., Acosta, N. , Sánchez , M., Mejía, E. (2007) Implementation of tsunami disaster prevention measures in the municipality of San Rafael del Sur, Nicaragua, AGU 2007 Talavera E. (2009). Personal communication Yamazaki, Y , Katayama, I, Strauch, W , Palacios, L, Traña, M, Cordonero, S. 2007. Development of Tsunami Hazard Maps along the Pacific Coast of Nicaragua, Eos Trans. AGU, 88(23), Jt. Assem. Suppl.

Detrital zircon U-Pb ages of the Puncoviscana Formation and its metamorphic equivalents in Catamarca and La Rioja, northwest Argentina

Adams CJ 1, Miller H 2, Aceñolaza FG 3, Toselli AJ 3

1 GNS Science, Private Bag 1930, Dunedin, New Zealand

2 Department für Geo- und Umweltwissenschaften, Sektion Geologie, Luisenstrasse 37, D-80333, Munich, Germany.

3 Facultad de Ciencias, Universidad de Tucumán, Miguel Lillo 205, 4000 San Miguel de Tucumán, Argentina.

The Puncoviscana Formation of northwest Argentina comprises Late Neoproterozoic-Early Cambrian, mostly clastic turbiditic sedimentary rocks, formed in a trough at least 1000 km long and several hundreds of kilometers broad at the proto-Pacific border of Gondwanaland. Low grade metasediments are widespread across Tucuman, Salta and Jujuy provinces, but medium and high grade metasediments probably extend the formation to the south and southwest, in Catamarca (Sierra de Ancasti, Sierra de Belén) and La Rioja. New U-Pb detrital zircon ages from metagreywackes in these latter areas are used to test the correlation with the classic Puncoviscana Formation to the north.

At the west scarp of the Sierra de Ancasti, above Catamarca, quartzofeldspathic schist (ANC5) has a typical Puncoviscana Formation zircon age pattern, with prominent age groups at 680-540 Ma (late Neoproterozoic- Early Cambrian), and 1120-880 Ma (late Mesoproterozoic-early Neoproterozoic) in approximate equal proportions. Significant age peaks occur at 550±6, 632±6, 668±6, 1034±20 Ma, with a small, scattered group at c. 740 Ma. This pattern is typical of the Puncoviscana Formation in Tucumán, and the youngest component, 550±6 Ma indicates a maximum stratigraphic age at the Precambrian-Cambrian boundary.

At Ampujaco (Sierra de Belén), a metagreywacke (AMP) has a more unimodal pattern, with 90% of ages in a Cambrian-late Neoproterozoic range (507-646 Ma), and only a few scattered ages at c. 800 and c. 1100 Ma. Significant age components occur at 514±8, 519±13, 539±4 and 556±7 Ma, of which the two youngest indicate a late Early Cambrian maximum stratigraphic age.

A biotite-hornfels metagreywacke at La Rioja (LRJ) is similar to the Ampujaco sample, with about 85% of ages in a 640-500 Ma age range, and significant age peaks at 525±3, 544±6 and 628±6 Ma. Again the youngest age component indicates an Early Cambrian maximum stratigraphic age.

The Ampujaco and La Rioja data resemble strongly unimodal Puncoviscana Formation age patterns near Rancagua and Carmen (Salta), which are dominated by Early Cambrian zircons of volcanicrystic origin (at the expense of Precambrian components). In this important respect, they are also similar to age patterns of the unconformably overlying Mesón Group, but the latter include distinctive mid-

Cambrian (510-500 Ma) components derived from Tilcarian igneous activity, and they contain a small but significant late Neoproterozoic (c. 600 Ma) component.

Over the extensive area of its outcrop, the Puncoviscana Formation and its higher-grade metamorphic equivalents demonstrate a consistent provenance pattern. This requires major sources, firstly a largely stabilised late Mesoproterozoic orogen, containing voluminous plutonic/metamorphic complexes, and with a hinterland of minor late Paleoproterozoic and Archean rocks, and secondly, an active late Neoproterozoic-Early Cambrian orogen, displaying an evolutionary sequence of volcanic and plutonic rocks. There is also a clear absence of any sediment sources from early Mesoproterozoic (1600-1300 Ma) rocks. In a larger Rodinia context, these source constraints suggest that major Puncoviscana sediment supplies most probably originates in the Brazilian craton and its marginal orogens.

Paleoclimate analysis and growth rings of fossil woods in the Serra Alta Formation (Upper Permian), Paraná Basin, southern Brazil

Alves LSR 1, Guerra-Sommer M 2

1 IVP/ FAPERJ, Rio de Janeiro, RJ, BRAZIL. e-mail: Laureen.Alves@gmail.com

2 Departamento de Paleontologia e Estratigrafia, Universidade Federal do Rio Grande do Sul - UFRGS, Av. Bento Gonçalves, 9500, Prédio 43127, Porto Alegre, RS, Brazil

The Paraná Basin, situed on the western border of South America, is an intracratonic basin filled with Paleozoic strata, Mesozoic sedimentary rocks and basalt lava and Cenozoic deposits. The Serra Alta formation includes a sucession composed of siltites, gray shales and carbonate concretions.

In terms of wood petrification, fossilization of organic structures can result in inorganic mineral replicas that preserve microscopic anatomical features. The occurrence of well-preserved silicified wood logs in the Upper Permian of the Paraná Basin, in outcrops of the Serra Alta Formation in the Rio Grande do Sul State, southern Brazil, allows for detailed systematic, paleoclimatic, paleogeographic and stratigraphic studies to be carried out.

Several diagnostic features observed in a studied fossil log allow its attribution to the genus Barakaroxylon, which comprise: a heterocellular medulla, primary endarch xylem, a secondary xylem with distinct growth rings, uniseriate bordered pits, uniseriate or partially biseriate medullar rays, with 14–15 cells high in tangential view, and crossing fields with large punctuations, isolated or in groups of 2 to 5.

Paleoxylological data recorded for the studied sequence points out to the dominance of morphogenera with canals in the medulla, related to Barakaroxylon and

Polysolenoxylon. These morphogenera are reported from the Barakar stage (Damuda Series) of India, and the Whitehill interval of South Africa.

The width of each growth rings change each year has been considered as a result of luminosity, temperature, rain fall and soil moisture variations. The simple presence of growth rings displaying similar features to those mentioned above can not be conclusively correlated to present day climates. However, a humid pluvial climate, with long-term growth seasons, can be safely concluded from the growth rings analyses, which further suggest a climate subject to cyclic variations from rainy tropical to humid temperate.

The Valdes submarine landslide: a landward facing landslide off southern Chile

Anasetti A, Krastel S, Weinrebe W, Klaucke I, Bialas J

Ifm-geomar, Wischhofstr. 1-3, 24148 Kiel, Germany, aanasetti@ifm-geomar.de

Submarine landslides are known for many different environments all over the world. They are one of the most important mechanisms for the configuration of continental margins and for transporting huge quantities of sediment downslope. Geophysical data acquired during cruise JC 23, aboard RV JAMES COOK in March/April 2008 and previous cruises cover most of the active Chilean continental margin between 33° and 37°S. Integrated interpretation of the data allowed identifying a number of landslides in the area. Unlikely to most other slides along continental margins, this one is situated on the eastern slope of a submarine ridge facing landwards. The setting of the landslide has an important impact of the associated tsunami wave field (first arrival of positive amplitude).

Geometrical parameters of the slide and the adjacent slope have been measured. The slide affected an area of 16.5 km^2 between ~1060 m and >1700 m water depths. The deposit is 6 km long, up to 3km wide and it's total volume is about 0,5 km^3. The landslide was induced by a single event. On account on this we presume its tsunami potential to be high. Situated on a steep ridge flank, the trigger mechanism is most likely closely related to the formation and evolution of the ridge. The ridge follows an elongated fault zone running app. parallel to the margin. This fault zone has a dextral component which, in combination with the faults elongation, implicates a compressional regime that is superimposed on the overall subduction-related compression and ultimately generated this ridge. Over-steepening (slope angle >6°) of rapidly accumulated sediments (high sedimentation rate) seems to be the most preconditioning factor of the slide. A weak layer may have acted as slipping surface as well. The most likely trigger for the landslide is one of the earthquakes occurring frequently in the area.

The Atacama Fault System and its role on the migration and deposition of Iron Oxide Copper Gold and Magnetite-Apatite ores: an evaluation from the Los Choros and Huasco valleys

Arévalo C 1, Creixell C 2

1 Servicio Nacional de Geología y Minería, carevalo@sernageomin.cl
2 Servicio Nacional de Geología y Minería

Introduction: The Atacama Fault System (AFS) is a margin-parallel, long-lived, continental-scale fault system which lies along the core of the Coastal Cordillera of northern Chile (Brown et al. 1993). This feature has accommodated normal and strike-slip displacements for at least 25 Ma during the Early Cretaceous and has been the locus of magma emplacement and the pathway for hydrothermal fluid migration leading to economic mineralisation like magnetite-apatite and iron oxide Cu-Au (IOCG) deposits (Grocott and Taylor, 2002; Sillitoe, 2003).

Although it is widely accepted that the AFS played a role on the emplacement of the ores, the nature of the control of the main fault traces and the subsidiary structures on the transport and final entrapment of mineralizing fluids is not sufficiently understood yet.

This contribution is an attempt to evaluate the linkage between the AFS and important magnetite - apatite and IOCG ore deposits in two localities, the Los Choros (29º20') and the Huasco (28º30') valleys from a structural perspective at a regional scale as part of current works held by the Servicio Nacional de Geología y Minería. In progress work will focus on local controls on the ore deposits and the way it determines the 3D geometry of the ore deposits.

The AFS in the Los Choros valley: The AFS is represented by a straight NNE trending mylonitic belt (La Higuera Shear Zone, LHSZ) at the margin of the multilayered El Tofo Plutonic Complex. High temperature pl-amphibole-biotite mineralogy implies that the mylonites are synplutonic. High angle mineral lineations contain pluton down sense of shear indicators. This displacement and the thickening of the individual plutonic layers toward the mylonitic belt are consistent with the creation of space through depression of the pluton floor at the hanging wall of the shear zone during early extensional displacements. The existence of the magnetite-apatite megadeposit (El Tofo deposit) within pluton host rocks at the thickened side of the intrusion is consistent with dilatant sites primarily caused by tip line folds during early extensional activity of the AFS.

Brittle faults bearing IOCG deposits locate to the west and east sides of the LHSZ. They are part of the El Tofo Fault System (ETFS). The westernmost structure is a straight, 50 km long, NNE trending, reverse fault which bounds the fault set in that direction named The El Tofo fault. It is the largest structure and produced the highest stratigraphic separation therefore it is considered the master fault of the system. A number of kinematic indicators along subhorizontal stretching

lineations within its fault trace shows left lateral sense of displacement which indicates that the strain absorbed by the surface is transpressional and highly partitioned between a sinistral and a reverse component. To the east, hematite-chalcopyrite rich NS, NW and WNW surfaces attributable to subsidiary R, T and R' fractures define a shortening axis at high angle with respect to the master fault so they can also be interpreted as acting under left lateral transpression.

The AFS in the Huasco Valley: Here the AFS is represented by the Colorados Fold and Thrust Belt (CFTB, Arévalo et al., 2003). This a 3 km thick, NNE trending belt of folds and thrusts continuous by at least 80 km. The easternmost Los Colorados fault is the master fault of the system. It hosts a number of IOGC deposits and rework the western margin of the Retamilla Plutonic Complex (ca. 126 Ma). In plan view all the west subsidiary faults merge into the master fault suggesting a positive flower cross section. Indicators along slicken lines and stretching lineations both on brittle traces and ductile calcareous foliation indicate left lateral sense of shear. West vergence contractional folds contained in the faults hanging walls indicate an orthogonal component of shortening and the lack of superimposition of these two fabrics implies that they are contemporary and indicative of left lateral transpression.

A pre transpression extensional stage is implied by 'young over old' stratigraphic separations exhibited by some of the reverse faults of the system. In fact, the restoration of a cross section to a precontractional stage produces a pluton dipping monocline consistent with a lateral drag fold adjacent to the Los Colorados fault during early extensional displacements. Such displacements would have helped the Retamilla plutonic Complex to create space through the depression of the pluton floor in a similar way than the El Tofo Plutonic Complex and a number of intrusions along the Atacama Coastal Cordillera (Grocott and Taylor, 2002). As in the LHSZ the wall block of the Los Colorados master fault host a mega magnetite-apatite ore deposit (Los Colorados deposit) which is also located in a probable dilation site during the synplutonic extensional displacements.

Conclusions: Both in the Los Choros and Huasco valleys a number of dilation sites associated with the AFS like tip line folds at the master faults wall blocks during early extensional stages related to pluton emplacement and subsidiary Riedel, Riedel' and T fractures during late left-lateral transpression have been identified. These sites constituted fluids traps where magnetite-apatite and IOCG ores were emplaced during the evolution of the AFS.

References

Arévalo C, Grocott J, Welkner D (2003) The Atacama Fault System in the Huasco Province, Southern Atacama Desert, Chile. In Congreso Geológico Chileno 10: CD ROM.

Brown M, Díaz F, Grocott J (1993) Displacement history of the Atacama fault system, 25°00'S 27°00' S, northern Chile. Geological Society of America Bulletin 105: 1165-1174.
Grocott J, Taylor G (2002) Deformation partitioning, magmatic arc fault systems and emplacement of granitic complex in the Coastal Cordillera, north Chilean Andes (25° 30' S to 27° 00' S). Journal of the Geological Society 159: 425-442.
Sillitoe R (2003) Iron oxide-copper-gold deposits: An Andean view. Mineralium Deposita 38: 787-812.

Provenance from cathodolouminescence colour spectra of detrital quartz in the Cambrian Mesón Group, NW Argentina

Augustsson C, Kocabayoğlu M, Chmiel H

Geologisch-Paläontol. Inst., Corrensstr. 24, 48149 Münster, Germany, augustss@uni-muenster.de

Detrital quartz grains contain source rock information that rarely is taken into account in provenance studies. Cathodoluminescence (CL) colour spectra characteristics depend on defects in the crystal lattice. As a result, quartz grains of different formation conditions develop different CL colours. To avoid the subjective optical colour identification, we applied the technique to measure CL colour spectra on detrital quartz grains from sedimentary rocks in NW Argentina. There, the Lower to Middle Cambrian Mesón Group overlies the Ediacarian to Lower Cambrian Puncoviscana Formation with an angular unconformity. Therefore, the Puncoviscana Formation could be a potential source for the Mesón Group. To elucidate possible recycling and to reveal the dominating source rock types of the Mesón Group we analysed the CL colour spectra of almost 500 detrital quartz grains in 21 sandstones and conglomerates from 5 samples of the Puncoviscana Formation (83 grains) and 16 samples of the Mesón Group (401 grains). The analysed rocks of the Puncoviscana Formation are turbiditic greywackes with fine to medium sand grain sizes in the framework. The phyllosilicate matrix exceeds 50 %. The sand particles are composed to 70-95 % of quartz and 5-30 % of feldspar. Lithic fragments are sparse and composed of metavolcanic and metasiltstone clasts. The analysed rocks of the Mesón Group are composed of shallow-marine fine- to middle-grained quartz-cemented sandstones and some granule-sized conglomerates. Both are mineralogically mature with > 90 % quartz and < 10 % feldspar grains in the framework. Lithic fragments are sparse in the sandstones and composed of metasiltstone and felsic plutonic rock fragments. In the conglomerates, also some volcanic rock fragments were found. The CL results of quartz from the Puncoviscana Formation reveal red and violet luminescing quartz (mean value: 28 %), as well as blue (49 %) and brown (23 %) quartz grains in varying proportions, indicating input from volcanic, plutonic

and magmatic source rocks to different degrees. In the Mesón Group, blue as well as red and violet luminescing quartz grains dominate (67 and 23 % respectively), pointing to plutonic and volcanic sources. Brown quartz occurs to < 1 % indicating low input from metamorphic source rocks. Most analysed quartz grains of the Puncoviscana Formation, but only few of the Mesón Group, contain Fe^{3+}, as revealed by a CL emission band at ca. 700 nm. Together with the large difference in metamorphic quartz grain content, this points to the absence of recycled quartz grains of the Puncoviscana Formation in the Mesón Group despite the similar rock fragment types. Instead the results imply that the detrital quartz of plutonic and volcanic origin in the Mesón Group derived from exposed magmatic rocks in the source areas. Hence, the large input of magmatic quartz grains into the Mesón Group may be due to regional unidentified source areas dominated by plutonic and volcanic rocks in Early to Middle Cambrian time.

Silurian Glaciations in the Amazon Basin and Chitinozoans (Trombetas Group) II

Azevedo-Soares HLC de

Prefeitura da Cidade do Rio de Janeiro, Secretaria Municipal de Educação, 2a CRE, RJ, hlcuevas@pop.com.br

In this work the Amazon Basin were been studing using the chitinozoan forms to explain the dymanic of environmental patterns during the Silurian. The temperature and salinity are the major environmental variables relevant to the course of the distribution and evolution the planktonic organisms like chitinozoans in the geological record. During the Silurian occured glacial episodes in the sedimentary basins over world. Specially in Amazon Basin (the Nhamundá and Pitinga Formations), the temperatures declined dramatically in three short-lived, the first glaciation occured during the early Aeronian (glaciation I), the second one between the latest Aeronian and the early Telychian (glaciation II), and the third one occured at least between the latest Telychian and the earliest Wenlock (glaciation III). Each one of the glaciations here described were the turning point to the first three Local Chitinozoans Assemblages (I, II and III) identified in the Nhamundá and Pitinga Formations. During the glaciation I two species have been disappeared: Euconochitina iklaensis and Spinachitina maennili, and eigth species have been appeared like Pogonochitina djalma and Bursachitina wilhelmi (endemic species). During the glaciation II twenty five species have been appeared like Euconochitina cruzi, E. patula, E. sulcata and P. inornata (endemic species) and Conochitina cf. C. acuminata, Cingulochitina convexa and Margachitina magaritana (cosmopolitan species). During the glaciation III have been disappeared twenty six species like Cyathochitina caputoi, Pogonochitina

djalma, Bursachitina wilhelm, Euconochitina cruzi, E. patula, E. sulcata, Cingulochitina convexa, Margachitina magaritana. In the case of these forms, we are convinced that the occurence of parasitism associated with some extintion was been caused by the inputs of the defrost of the polar ice cap. These inputs are related before in the litterature. The parasitism occured in species like Cyathochitina caputoi, Conochitina cf. C. acuminata, Pogonochitina djalmai and P. inornata.

Irrigation agriculture in the western coastal desert – an anthropogenic sediment trap

Baade J, Hesse R

Department of Geography, Friedrich-Schiller-University Jena, Germany cub@uni-jena.de

The fluvial transfer of sediment from the land surface to the ocean is a complex process and in many regions of the world this process has been strongly influenced by men. In the humid regions of the world the onset and expansion of agriculture went along with deforestation, accelerated soil erosion, and an increase in sediment yield. In arid regions, however, agriculture is based on irrigation and thus often the withdrawal of water and sediment from the rivers. Several meters thick irragric anthrosols are evidence of the continuous and long lasting trapping of sediments on irrigated fields.

Investigations of irragric anthrosols in the catchment of the Rio Grande de Nasca, Southern Peru (11,164 km^2), have shown that trapping of sediments started around 3.300 cal BP and irrigation schemes were fully established in Pre-Columbian times. Volumetric mapping of irragric anthrosols in the Rio Grande catchment shows that 152 mio m^3 of sediment has been intercepted on its way from the western slopes of the Andes to the Pacific Ocean by diversion of water from the rivers for irrigation. From this volume the minimum long term sediment yield from the upstream catchment to the foot of the Andes for the last approx. 2,000 yr. can be calculated to be 13 t km^{-2} a^{-1}. However, this value is biased by i) the sediment trap efficiency of the irrigation system, probably being much lower than the water use efficiency and ii) the fact that during extreme runoff events remobilization of irragric anthrosols occurs. This paper discusses ways to account for these problems and estimates of Late-Holocene catchment denundation rates.

Natural and anthropogenic concentration and distribution of heavy metals in superficial water and current sediment in the Formoso river basin, Buritizeiro Municipality - MG, Brazil

Baggio H 1, Horn, AH 2

1 Laboratory of geology and geomorphology – LGG-NPA, University of Montes Claros UNI-MONTES/Brazil, hernandobaggio@yahoo.com.br

2 Laboratory of environmental geochemistry - NGqA-CPMTC-IGC, Unversity of Minas Gerais – UFMG/Brazil

Introduction: The Formoso River is an important tributary of The São Francisco River in the Northwest of Minas Gerais State. There are more than 100 families who live and depend exclusively on the natural and environmental resources of its basin. It is inserted in the Cerrado Biome where its waters drain large agropecuary landed estates, what directly influences the physicochemical characteristics of superficial waters and stream sediments.

Taking into account the natural particularities and the anthropogenic characteristics, this study aimed to asses the concentration and distribution of heavy metals: Cu, Cd, Cr, Ni, Pb, Zn, Al, Mn, Fe, along the river longitudinal profile, correlating their presence to the natural environments and to anthropogenic interferences, inferring the environmental risks and the use restrictions of these metals.

Localization and characteristics of drainage of the Formoso Rive basin: Geographically, the sub-basin of the Formoso River is positioned in the Southwestern portion of the municipal district of Buritizeiro, more precisely delimited by the coordinates of 17° 25' and 17° 56' of latitude S and 44° 56' and 45° 26' of longitude W; draining an area of 826 km² and integrated part of the São Francisco River hydrographic basin. The Formoso River can be classified as an open channel, and his main flow is of the turbulent type with numerous rapids. In general, his turbulent flow is characterized by a variety of secondary movements and currents, contrary to the downstream part of the river. Along the fluvial channel, the flow varies between turbulent currencies and the turbulent rapids; this last one restricted to the passages of higher speed, in the great majority on the upper to middle segment of the course. The dynamic of the hydrographic basin of the Formoso River is responsible for the fluvial sedimentation, which includes the removal processes, transport and sedimentation of the particles in suspension. Some peculiar aspects of this fluvial sedimentation that happen mainly in the higher and lower segments are related to the intense removal of slope-debris, whose main cause is agriculture. Another fact that increases the sedimentation taxes is the construction of local highways and roads.

Methodology: Environmental quality parameters in-situ and total heavy metals were analyzed in 40 samples of water and the results were compared to the legislation of CONAMA resolution 357/05. The research revealed that in some points the levels of Fe, Al, Mn, Cd, and Cr are over the recommended by the resolution 357/05, OD,

T, pH and turbidity values are also over the established level. The Cu, Cd, Cr, Ni, Pb and Zn parameters were analyzed in 22 sediment samples using the chemical partial acid extraction technique and ICP-OES reading and the results were compared to the CONAMA resolution 344/04. It was found that the levels of Cd and Cr are above the levels recommended by this resolution. Mineral characterization was done by X-Ray diffractometry and geochemical lithotypes analysis was done by ICP-AAS. For the cartographic elaboration SIG-SPRING was used to capture natural landscapes. The presence of these elements in the water column shows a natural enrichment throughout the longitudinal profile whose main sources are the lithotypes. There is a link between the lithopedologic variable, the typology of the fluvial channel, the hydrodynamic of the basin and the distribution and transport of metals throughout the longitudinal profile of the river.

Results: The levels of concentration of Cd, Cr, Cu, Zn, Ni and Pb in the water compartment are mainly related to the anthropogenic interferences and to a natural contribution of geologic order. In sediments the argillaceous fraction is retaining high concentrations of Cd and Cr. The morphologic characteristics of the fluvial channel and the hydrodynamics of the basin have played an important role as a mechanism for the distribution and transport of metals in the sediments. In a general way the data of the selected heavy metals analyzed in the river bottom sediments show a very heterogeneous comportment from very high to very low concentrations. The sampling points with the highest concentrations are located in the areas directly influenced by agricultural and cattle creating activities. These places receive directly the metal-organic residues generated by the enterprises, transported by wind the pluvial waters. The sampling points with lower concentrations are localized in the middle to lower course of the river. It is stood out, once again, that until the moved away points of the area of direct influence presented lines of those heavy metals. In a general way, all the investigated heavy metals in sediment show a permanent enrichment along the longitudinal profile, showing the solubilization oh the smaller amount of selected elements of the lithotypes of the rocky substratum liberated by the processes of physical and chemical intemperism. The morphologic characteristics of the fluvial channel and the general hydrodynamic conditions of the basin are the most important mechanism for the distribution and transport of the selected metals in the sediments. The strong correlation among the six analyzed metals in relation to the profile and to the geological and geomorphologic compartments. It is nearly clear that the hydrogen potential is one important control mechanism for their sediment concentration in the Formoso River system determining their mobility. Afterwards presented, show the concentration and distribution of the selected heavy metals in sediment samples along the longitudinal profile of the Formoso River in correlation com lithology, and human activities.

Conclusions: The correlation was evident enters support metals Fe, Al, Mn and the perception of this situation in the behavior of metals of support in relation to its

concentrations. The presence of these elements in the column d' water shows a natural enrichment throughout the longitudinal profile, whose principal sources are the lithotypes. The chemical analyses of metals weighed in superficial waters demonstrate that the Cd and Cr are the elements whose concentrations had violated Resolution CONAMA 357/05; how much to other metals - Cu, Zn, Pb and Ni -, the concentration levels had not violated this legislation. However, the levels of concentrations of these metals demand attention, therefore for some metals the concentration levels meet next to the values of reference very. The levels of concentration of Cr, Cu, Zn, Ni and Pb in compartment water are happened, mainly, of the contribution generated for the anthropogenic interferences and of a natural contribution of geologic order. The results of the chemical analyses for the selected heavy metals in the river sediments, demonstrate that the loamy (argillite) fraction is keeping very high concentrations of those metals, especially Cd and Cr, which passed level 1 for TEL for sediments (Resolution CONAMA 344/04). The other analyzed elements, especially Pb, Zn, Ni and Cu show concentrations lower than the limit determined by that resolution, but they demand special attention, because their concentration levels are close to the recommended limits. The loamy fraction of the sediments is the main portion of the conducted active geochemical, as much of natural order as anthropogenic. In a general way, all the investigated selected metals show in the sediments a natural enrichment by natural liberation by physical and chemical intemperism along the longitudinal profile, tends as main source the trace minerals from the several rocks. The morphologic characteristics of the fluvial channel and the hydrodynamic features of the basin are important mechanism for the distribution and transport of the metals the sediments. The obtained results confirmed a higher concentration of some heavy metals and in the sediments of the river, and this can connected to different human activities in this Sub-Basin. This is probably a result of the metal-organic residues generated by the commercial agriculture. Taking these results in consideration, a possible suggestion is the implantation of a strong monitoring program for all the analyzed heavy metals and additional investigationof soil, plant and animal metal concentrations. The susceptibility degree of heavy metals contamination of the natural environments that constitutes the basin was demonstrated by a predisposition letter for the environmental risk. In conclusion, the basin of the Formoso River is made up of a fragile natural environment. The varied types of anthropogenic interferences, especially the commercial agriculture, have contributed significantly for its environmental degradation. The hydric resources and the aquatic environments have been the most affected.

We thank the following institutions for logistical and financial support: UNIMONTES/LGG-NPA, UFMG/IGC-CPMTC, CDTN-CNEN, FAPEMIG and also all that contributed to the execution of this work in a certain way.

References

Alloway BJ, Ayres DC 1997. Chemical Principles of Environmental Pollution, 2 ed.

Ed. Chapman & Hall, New York.
Kabata-Pendias A 1995. Agricultural problems related to excessive trace metal contents of soil. In:
Solomons W et al., 1995. Heavy metals: problems and solution. Berlin, Springer, 1995. p. 3-18.
Krauskopf KB 1976. Introduction to geochemistry. NewYork, McGraw-Hill 721 p.
Salomons W 1995. Long-term strategies for handling contaminated sites end large-scale areas. In: Salomons W et al. 1995. Biogeodynamics of pollutants in soil and sediments: risk assessments of delayed and non-linear responses. Berlin, Springer, 1995. p. 1–52.

Some materials used in Buritizeiro archeological site- MG, Brazil and its possible regional origin

Baggio H 1, Horn AH 2, Rodet MJ 3, Rodet,J 3 Trindade,WM 2

1 Laboratory of geology and geomorphology - LGG-NPA, University of Montes Claros, Brazil, hernandobaggio@yahoo.com.br
2 Laboratory of environmental geochemistry-NGqA-CPMTC-IGC, Univ. of Minas Gerais, Brazil
3 Laboratory of morphdynamic continental and coastal - Department of Geolgy, University de Rouen UMR-CNRS, France

General features: The area in study is totally inserted in the hydrographic basin of the São Francisco River, placed within the municipal limits of Buritizeiro district, northwestern part of Minas Gerais State. The geographical limits are 16º30' to 18º00 of Lat. S and 45°40' to 44°57' of Long. W.

The archeological Indian cemetery site, Caixa d'Água, is localized at the Manuel Conceição de Melo street s/n, central area of Buritizeiro, between the UTM coordinates 0504605E and 8081527N. This prehistorically Indian site is occupying an area of approximately 1.2 ha, partially covered by houses and asphalt. From the lithological point it is part of the Três Marias Formation (Neoproterozoic Bambuí Group), whose morphologic features are represented by a scarp of erosive flaw sculpted by the river, and the current vegetation is formed by "capoeira". The site is in the open air, and is one of the best conserved along the São Francisco River Valley. Datings of ^{14}C in organic co-existing materials show ages up to 6.000 BP.

The populations (fishermen) who lived in the area took advantage of the natural resources of the river and the vegetation in its basin, so this study tries to find out more information about their habits, their source of raw material and their routes in search of these materials, as well as a better knowledge about the paleogeoenvironmental conditions during the Upper Pleistocene, in an attempt to recover the natural landscape and the population habits.

Human aspect: The relationship between man and his environment is a fundamental element for the knowledge of the ancient populations. The landscape is also the result of a specific evolutionary process, which depends on the natural history of the place in study, involving aspects like geology, climate, biology and human beings. Before the industrialization, the life of the human groups was always connected to the natural resources: at a first phase, the groups lived on what the nature offered (hunters, fishermen, collectors), and at a second phase, these groups domesticated nature partially, planting and cultivating (shepherds, horticulturists).

Field work: At a first campaign lithic materials such as anvils, beaters, cutting chips and plane stones for polishing and other lithic artifacts were collected from the site. At a second, samples from lithologic units were gathered in the surrounding regions where there were found aspects of use and also materials similar to those used in the site. These samples were described macroscopically; thin plates were made and investigated by optical, microprobe and electron microscope. All this aspects were used to compare the materials and create a regional and local geological and geomorphological map to reveal the probable places of occurrences and possible sources and pathways for the transport and collection of these materials which had the important role of providing those populations.

Results: Four distinct sources of lithic material used by the Buritizeiro man were identified in this research as follow:
a. Superficial deposits of gravel/pebble - tertiary/quaternary - in the surroundings, used mainly for simple cutting tools;
b. Volcanic-Sedimentary material of the Mata da Corda Group – Upper Cretaceous such as volcanoclastic rocks used in important everyday use tools (scrapers, blades for cutting, fishhooks and arrowheads);
c. Sandstones - Areado Group - Inferior Cretaceous - arenite used in tools for polishing and finishing of lithic instruments;
d. Arkose of the Bambuí Group, Três Marias Formation – Neoproterozoic (mortuary flagstones, anvils, mortars, crushers, cutting tools).

Conclusion: All this data, compiled in a georeferenced map model of the ancient situation is a first stage in preparing a future 3 D land evaluation and the insertion of geochemical, petrographical, mineralogical and sedimentological investigations in this map. This may be fundamental to try to elucidate which were the main routes established by those populations in search and collection of the lithic material, that were used by them as tools and utensils.

We thank the following institutions for logistical and financial support:
UNIMONTES/LGG-NPA, UFMG/IGC-CPMTC, UMR-CNRS, FAPEMIG and also all that contributed to the execution of this work in a certain way.

References

Baggio H, Horn HA, Trinidade WM, Ribeiro EV, 2006. O Grupo Mata da Corda na Bacia do Rio do Formoso e suas feições Morfológicas Correlatas. VI Simpósio Nacional de Geomorfologia. Goiânia. V.1. p, 304.

Collins MR, Sapiro G, 1987. Compilation of human influenced and natural soils at the San Luis. Archaeological sites. Florida. Soil Science Society of American Journal, Madison, v.37, p.149- 156.

Prous A, Baggio H, 2007. O homem de Buritizeiro: Revista Minas Faz Ciência. Belo Horizonte. Ed. FAPEMIG. 2007, N°31 (Jun - agost/2007): 26-29.

Salgado-Labouriau ML, 1997. Late Quaternary palaeoclimate in the savannas of South America. Journal of Quaternary Science, 12(5): 371-379.

Timing of crust formation and recycling in accretionary orogens: The detrital zircon U-Pb and Hf, and the whole-rock Nd isotope evidence of Devonian to Permian turbidite deposits of the Gondwana margin in northern Chile

Bahlburg H 1, Vervoort JD 2, Du Frane SA 2

1 Institut für Geologie und Paläontologie, Münster University, 48149 Münster, Germany bahlbur@uni-muenster.de

2 School of Earth & Environmental Sciences, Washington State University, Pullman, Washington 99164-2812, USA

Accretionary orogens are considered major sites of formation of juvenile continental crust. In the central and southern Andes this is contradicted by two observations: siliciclastic fills of Paleozoic basins in the central Andean segment of the accretionary Terra Australis Orogen consist almost exclusively of mature sandstones and shales; and magmatic rocks connected to the Famatinian (Ordovician) and Late Paleozoic magmatic arcs are predominantly felsic and characterised by significant crustal contamination and strongly unradiogenic Nd isotope compositions. Evidence of juvenile crustal additions is scarce.

We present laser ablation (LA)-ICPMS U-Pb ages and LA-MC-ICPMS Hf isotope data of detrital zircons from seven Devonian to Permian turbidite sandstones incorporated into a Late Paleozoic accretionary wedge at the western margin of Gondwana in northern Chile. The combination with Nd whole-rock isotope data permits us to trace the evolution of the South American continental crust through several Proterozoic and Paleozoic orogenic cycles.

The analyzed detrital zircon spectra reflect all Proterozoic orogenic cycles representing the step-wise evolution of the accretionary SW Amazonia Orogenic System between 2.0 and 0.9 Ga, followed by the Terra Australis Orogen between 0.9 and 0.25 Ga. The zircon populations are characterized by two prominent maxima reflec-

ting input from Sunsas (Grenville) age magmatic rocks (1.2-0.9 Ga) and from the Ordovician to Silurian Famatinian magmatic arc (0.52-0.42 Ga). Grains of Devonian age are scarce or absent from the analyzed zircon populations.

The Hf isotopic compositions of selected dated zircons at the time of their crystallization ($\varepsilon_{Hf(T)}$; T=3.3-0.25 Ga) vary between –18 and +11. All samples have a significant juvenile component; between 20 and 50 % of the zircons from each sample have positive $\varepsilon_{Hf(T)}$ and can be considered juvenile. The majority of the juvenile grains have Hf depleted mantle model ages (Hf T_{DM}) between 1.55 and 0.8 Ga, the time of the Rondonia-San Ignacio and Sunsas orogenic events on the Amazonia cration. The corresponding whole-rock $\varepsilon_{Nd(T)}$ values are between -8 to –3 indicating a mixture of older evolved and juvenile sources. Nd depleted mantle model ages (Nd T_{DM}) are between 1.5 and 1.2 Ga and coincide with the zircon Hf model ages.

Our data indicate that the Paleo- and Mesoproterozoic SW Amazonia Orogenic System, and the subsequent Neoproterozoic and Paleozoic Terra Australis Orogen in the region of the central and southern Andes developed following two markedly distinct patterns of accretionary orogenic crustal evolution. The SW Amazonia Orogenic System developed by southwestward growth over approximately 1.1 Ga through a combination of accretion of juvenile material and crustal recycling. In contrast, the central Andean segment of the Terra Australis Orogen evolved from 0.9 to 0.25 Ga in a relatively fixed position without the accretion of oceanic crustal units or large scale input of juvenile material to the orogenic crust. Here, recycling mainly of Mesoproterozoic continental crust has been the dominant process of crustal evolution.

Exploring the initiation of subduction and the coeval evolution of sedimentary basins-examples from the Phanerozoic Andean margin

Bahlburg H

Institut für Geologie und Paläontologie, Münster University, Germany, bahlbur@uni-muenster.de

The subduction of oceanic lithosphere is the main driver of plate tectonics. A largely unresolved problem concerning the present understanding of plate tectonics and the evolution of sedimentary basins is the mechanism by which subduction zones are initiated at plate margins, and passive margins in particular. Apart from some numerical considerations there are virtually no field observations and case studies dedicated to elucidate this transition and revolution.

Many studies of accreted terranes conclude that a subduction zone "jumped" from the colliding side of a terrane to the hitherto passive side. But it remains unclear by which mechanism this new subduction zone forms, and how one would recognize this process in the sedimentary record and geological architecture of the transforming passive margin basin. A good indicator of a subduction system having been

initiated is represented by a relatively sudden influx of volcaniclastic material from the evolving arc. But there is a considerable time lag between the initiation of subduction and the onset of arc magmatism. Flat angle subduction systems are even more problematic as there will be no volcaniclastic influx.

After initiation, subduction zones become self-sustaining after c. 100 km of convergence; nearly half of the presently active subduction zones were initiated in the Cenozoic. Subduction can begin by two principal mechanisms, either by spontaneous failure of the lithosphere, or as an induced initiation brought about by compressional forces including jamming of subduction zones during terrane collision leading to an oceanward jump of the new subduction zone (Stern 2004).

Induced nucleation of subduction zones including a polarity reversal occurred in the formerly south-dipping Solomon Island subduction zone which jammed after collision of the Ontong-Java oceanic plateau 4 Ma ago. Examples of induced nucleation involving transference include the double transference event having ocurred during the Paleozoic in the Argentinian and Chilean Andes in the course of the stepwise accretion of the Cuyania and Chilenia terranes (Ramos 2004).

Spontaneous nucleation of subduction zones by passive margin collapse may be caused by cooling and sedimentary loading of young passive margins, leading to the detachment of the oceanic from the continental lithosphere (Cloetingh et al. 1989). Transform collapse and forearc spreading may result from the activation of margin faults and fracture zones in the transition zone between oceanic and continental lithosphere (Mueller & Phillips 1991). Van der Lee et al. (2008) find a near-vertical low-velocity zone in the mantle below eastern North America at depth between 700 to 100 km. This zone they interpret as a hydrous "dike" poduced by water infiltration (<1%) from the sinking Farallon plate subducted in the Mesozoic under western North America and now extending underneath the eastern continent at depths of c. 1000 km. The inferred degree of mantle hydratisation seems sufficient to permit the North American plate to eventually rupture approximately along the east coast and above the hydrous "dike", and initiate a new subduction zone at this continental margin.

Transitional cases between the two principal modes of subduction initiation may include cases akin to the tectonic framework of the southern passive margin of India and the southward adjacent oceanic lithosphere. India is a large terrane which is still colliding with Asia. Jamming of the subduction zone by buoyant Indian continental lithosphere leads to compressive deformation of the boundary between the Indian and Australian plates and increased seismicity in the Indian ocean south of India. A combination of passive margin collapse under a thick sedimentary wedge and rupture of the transition between the Indian and Australian plates may here in the future lead to the initiation of a new subduction zone.

Many of the open questions concerning subduction initiation can only be addressed on land in ancient mountain belts. A prime candidate for the study of different subduction initiation processes is the Phanerozoic continental margin of South America in the region of the central and southern Andes. This margin is considered

the proto-type active continental margin. However, Chile north of 28°S records the development of a non-subducting and probably passive margin during the Devonian and Early Carboniferous (Bahlburg & Hervé 1997; Chew et al. 2007). Subduction and magmatism re-started around 345 Ma in northern Chile and propagated southward to central Chile (310-300 Ma) and northward to Peru (Late Carboniferous-Permian; Bahlburg et al, under review). The causal mechanism was very likely spontaneous nucleation, involving either passive margin or transform collapse. During the initiation of subduction, large scale uplift and denudation at the margin, similar to Cenozoic cases in the western Pacific (Gurnis et al. 2004), is indicated by Early Devonain transgression over Late Ordovician coarse-grained equigranular granites formed at greater crustal depths. In northern Chile, this subduction system ended again in the Permian.

Another example at this margin is the beginning of the Andean cycle of subduction and mountain building in the Late Triassic. In general terms, the onset of basin formation and magmatism in the Late Triassic was connected to extensional tectonics and basins at least from northern Peru to central Chile (Jaillard et al. 2000). The sedimentary record reflects initial continental deposition in relatively small extensional basins in the Late Triassic giving way to fossiliferous marine siliciclastics and predominant limestones as a result of Early Jurassic transgression of the evolving ensialic back-arc basin. In northern Chile, the newly formed magmatic arc was located in the Cordillera de la Costa and represents a quasi-spontaneous westward shift of arc magmatism of 150 to 200 km from the Late Carboniferous and Permian arc position. This shift is oberved from southern Peru to northern Chile along more than 1500 km of continental margin. The location of the Jurassic arc at the present coast indicates that the Jurassic fore-arc overstepped the Late Paleozoic subduction zone by its estimated width of 200 km. Since the Cretaceous this fore-arc has been eroded by subduction erosion which caused the subsequent magmatic arcs to step inland. Geochemical and geophysical data indicate that the Jurassic arc and forearc are the product of a major event of formation of juvenile crust connected to crustal extention (Franz et al. 2006). It was potentially connected to spontaneous subduction initiation by forearc spreading sensu Stern (2004), in a way analogous to subduction initiation in the Jurassic in the Coast Range of California, or the Eocene oceanic Izu-Bonin-Mariana arc.

References

Bahlburg H, Hervé F (1997) Geodynamic evolution and tectonostratigraphic terranes of NW-Argentina and N-Chile. Geol Soc Am Bull 109: 869-884.

Bahlburg H, et al (under review) Timing of accretion and crustal recycling at accretionary orogens: The U-Pb, Hf and Nd isotope evidence of Devonian to Permian turbidite deposits of the Gondwana margin in northern Chile. Earth-Sci Rev.

Chew D, et al (2007) U-Pb geochronologic evidence for the evolution of the Gondwanan margin of the north-central Andes. Geol Soc Am Bull 119: 697-711.

Cloetingh S, et al (1989) On the initiation of subduction zones. Pure Appl Geophys 129: 7-25.

Franz G, et al (2006) Crustal evolution at the centarl Andean continental margin: a geochemical record of crustal growth, recycling and destruction. Frontiers Earth Sci 1: 45-64.

Jaillard E, et al (2000) Tectonic evolution of the Andes of Ecuador, Peru, Bolivia and northernmost Chile. 31st Int Geol Congr: 481-559.

Mueller S, Phillips J (1991) On the initiation of subduction. J Geophys Res 96 B1: 651-665.

Ramos V (2004) Cuyania. an exotic block to Gondwana: review of a historical success and the present problems. Gond Res 7: 1009-1026.

Stern R (2004) Subduction initiation - spontaneous and induced. Earth Planet Sci Let 226: 275– 292.

Van der Lee S, et al (2008) The role of water in connecting past and future episodes of subduction. Earth Planet Sci Let 273: 15-27.

Distinct magma plumbing and storage systems inferred from mineral chemistry and geothermobarometry of four volcanic centres in the central Andes

Banaszak M 1, Wörner G 1, Botcharnikov R 2, Holtz F 2, Hora J 3

1 GZG, Abt. Geochemie, Goldschmidtstr.1, 37077 Göttingen, Germany

2 Inst. f. Mineralogie Universität Hannover, Callinstr.3, 30167 Hannover, Germany

3 Dept. Geology and Geophysics, Univ. of Wisconsin-Madison, Madison, WI 53706, USA

The Central Andes reveal different volcanic activity defined by the morphology and composition. Besides high volume ignimbrite centres and small volume monogenetic lava extrusions Andean magmatic activity is dominated by classic volcanoes as symmetric stratocones and dome complexes lacking radial symmetry. We investigate two latter types of volcanic systems along Central Volcanic Zone to constrain differences in their plumbing and storage systems. We focus multidisciplinary research on the existence of magma chambers underneath volcanoes. We combine our geochemical studies with experimental petrologic and geophysical methods (for details see Botcharnikov et al. and Brasse et al. LAK Program) to constrain thermodynamic conditions and the depth of magma chambers.

Observed variability in volcano evolution, with respect to compositional range and eruption rates, points to the differences in plumbing systems, recharge frequency, volatile content, magma stagnation depth and reservoir sizes as well as crustal structure. To verify the significance of these factors we compare mineral chemistry and geothermobarometry results for four end-member systems: El Misti (<112 ka) and Lascar (<43 ka) are characterized by high eruptive rates (~0.8 km^3/ka) and andesitic to dacitic composition. Parinacota (163 ka) shows low eruption rates which

to dacitic composition. Parinacota (163 ka) shows low eruption rates which increased in time (0.5 to 1.0 km^3/ka) and consists of five phases, varied from andesite to rhyolite with change to basaltic andesite and andesite compositions after flank collapse. In contrast, the Taapaca dome complex (1270 ka) generated rather uniform dacitic composition with lowest eruptive rates (0.024 km^3/ka).

Mineral compositions reveal significant differences between investigated volcanoes. The youngest volcanoes El Misti and Lascar demonstrate - at a given magma composition - more calcic plagioclase composition (An40-85) compared to longer-lived Parinacota and Taapaca (An25-65). Tschermakitic amphibole composition dominates in El Misti and Lascar lavas, whereas Taapaca and Parinacota are characterized by magnesio-hornblende and Ti-rich hastingsite. Two amphibole populations with distinct compositions were found in all Taapaca dacites and several samples from Parinacota and Lascar. Depending on the degree of differentiation, magnetite and ilmenite compositions yield lowest Mg/Mn ratios from Taapaca dacites and more evolved Parinacota lavas. Presence of two different Mg/Mn ratios observed in Fe-Ti-oxides from several eruptive units of Parinacota and Lascar indicates crystallization from distinct magma batches.

Application of hornblende-plagioclase thermometry, magnetite-ilmenite thermo-oxy-barometry and amphibole barometry in connection with experimental constraints of crystallization conditions for these volcanoes reveals significant differences in the magma stagnation levels and conditions of magma differentiation and presumably the plumbing system.

Hornblende-plagioclase thermometry for El Misti and Lascar gave a large and continuous temperature interval of crystallization from ~850 to 980°C is in agreement with the range obtained from magnetite-ilmenite (840-970°C). Oxygen fugacity estimates show a limited range for both volcanoes from 0.7 to 1.9 log units above NNO. Distinct magma batches at Parinacota, defined by their chemistry, distinct Ar-Ar-ages and eruption characteristics, show three narrow hornblende-plagioclase crystallization temperature ranges around 730°, 840°, and 920°C. Thermo-oxybarometry for Parinacota document diverse temperature-oxygen fugacity ranges for the different compositional units. The highest temperatures and lowest oxygen fugacity appear in lavas erupted after flank collapse (880-1010°C, 0.2-1.1 log units above NNO). The most differentiated Parinacota lavas yield oxidized conditions at 1.7 to 2.0 log units above NNO values at temperatures of 780 to 830°C. At Taapaca units of largely different age, temperatures and oxygen fugacity determined from magnetite-ilmenite vary between 780 and 930°C at oxidizing conditions from 1.0 to 2.0 log units above NNO. The lowest temperature range obtained from hornblende-plagioclase inclusions in sanidine megacrysts reveals a peak at 730°C. Temperatures calculated from host hornblende/hastingsite and plagioclase yield three temperature intervals at 730°, 830° and 950°C. Natural hornblende could be experimentally reproduced from the dacite composition at temperatures range from 720 to 760°C and pressures between 2 and 3 kb. Hastingsite crystallized only from andesitic composition in our experiments for Parinacota at 950 °C and pressure of 3 kb. Al-in-

hornblende barometry applied to alkali feldspar-bearing lavas yield pressures consistent with experimental results for Taapaca dacite from 1.2 to 2.8 kb and 0.4 to 2.0 kb for Parinacota rhyolite. These estimates correspond to shallow magma reservoirs, about 6 to 8 km below Taapaca for all stratigraphical units and 3 to 7 km for most differentiated magmas under Parinacota. Al-Ti thermobarometry on amphibole from more mafic El Misti, Parinacota and Lascar magmas yield crystallization levels <20 km depth.

The preliminary results obtained from mineral chemistry and geothermobarometry show considerably differences in magma plumbing and storage systems reflected in morphology and composition of the investigated systems. Young and "fast" volcanoes El Misti and Lascar that produce a narrow compositional range of erupted lavas reflect high magma recharge frequency and high water contents and probably have similar feeding systems, and magma stagnation levels of 5 to 10 kb. Long-lived Taapaca volcano with uniform dacitic composition has magma stagnation level of 2 to 3 kb, low water contents and recharge rate. The occurrence of sanidine megacrysts and two amphibole populations in Taapaca lavas suggests mixing between magmas, initially crystallized at different conditions, in a thermally buffered steady state system. In contrast, Parinacota volcano produced broadest compositional spectrum mostly affected by changing of the plumbing system, different magma stagnation levels and recharge through time. Combining estimations of pressure with temperature for all Ar-Ar-dated stages of Parinacota allow the reconstruction of the depth-time-evolution of the magmatic system from deep and varied to shallow and focused.

An assessment to block rotation in northern South America: new paleomagnetic data of the Santa Marta massif, northern Colombia

Bayona G, Jiménez G, Silva C

Corporación Geológica ARES, Colombia, gbayona@cgares.org

The Santa Marta massif (SMM) is a complex terrain located in the NW margin of South America, bounded by the left-lateral Santa Marta fault at west and the right-lateral Oca fault at north. The SMM is cored by Precambrian metamorphic and Jurassic intrusive rocks, whereas along the SE flank, crop out Jurassic volcanic rocks overlying uncomfortably by Cretaceous limestones.

Paleomagnetic analysis of 30 sites, sampled in the Jurassic and Cretaceous units, uncovered three principal magnetic components. Component '*a*', isolated at low coercivities/temperatures, has north declination and moderate-positive inclination, representing the actual field direction (*n* 11, *D* 352.3, *I* 25.6, *k* 52.2, α_{95} 6.4). Characteristic components '*c1*' and '*c2*' were isolated at high coercivities/temperatures.

Component '*c1*' was uncovered in Cretaceous and some Jurassic rocks, shows northward declination and low-positive inclination (*n* 6, *D* 8.7, *I* 8.3, *k* 24.5, $\alpha 95$ 13.8) after tilt correction by Cretaceous bedding; we interpreted '*c1*' component as Lower Cretaceous event. Component '*c2*' was uncovered only in Jurassic rocks of 9 sites and shows, after two tilt correction steps, a northeast declination and moderate-negative inclination. However, only two sites have reliable bedding data of Jurassic rocks and they are just below the Cretaceous unconformity; therefore we calculated the mean direction using 18 specimens of these two sites (*n* 2, *D* 20.7, *I* -24.3, *k* 44, $\alpha 95$ 5.1). We interpreted '*c2*' component as a Middle Jurassic event of magnetization.

Middle Jurassic and Lower Cretaceous directions, isolated in areas away of the Santa Marta fault, suggest slight clockwise vertical-axes rotation of 17.3°±12.7°. The Jurassic component suggests northward translation of the SMM from Paleolatitude -7.3°, close to the magnetic equator in the Cretaceous and northern latitudes through Cenozoic.

Late Quaternary pollen records and their importance for Global Change research - Examples from tropical South America

Behling H

Department of Palynology and Climate Dynamics, Albrecht-von-Haller-Institute for Plant Sciences, Unive. of Göttingen - Germany, Hermann.Behling@bio.uni-goettingen.de

High-resolution palaeoecological records have a great potential in reconstructing past environmental changes in detail as an important contribution to the Global Change research. Studies on late Quaternary vegetation and other environmental dynamics help us to understand modern and future ecosystem changes. Several examples from South America will be presented.

Studies from marine cores off northeastern Brazil and in the Cariaco Basin as well as other continental records from southern Brazil show that the response of ecosystems on large scale climate change can be within centuries or decades.

Long pollen records from Carajas (Serra Norte) in eastern Amazonia show that marked changes between savannah vs. forest occurred between glacial and interglacial cycles. Pollen and spore diversity, as an indicator of past plant diversity, indicate that an almost complete interglacial period is needed to get a return to high plant diversity within in the rain forest.

High-resolution records from the coastal region in southeastern and southern Brazil reflect a relatively short warm and very humid period at the end of the Younger Dryas period, reflecting the possible slow down of the thermohaline circulation in the northern Atlantic.

Detailed studies from Cambara do Sul record in southern Brazil, reflect marked

vegetational changes during the late Holocene, indicating the wettest Holocene period, and strong human impacts during post-Columbian periods, forming secondary forests during the last centuries.

These palaeorecords indicate how tropical ecosystems evolved to what they are today. Furthermore they show how sensitive ecosystems are to climate change and how ecosystem responded to natural and anthropogenic environmental changes during the past. This knowledge will help us to understand how ecosystems might change under the ongoing Global Change.

Tholeiitic and calc-alkaline volcanism associated to the active continental margin of the Miocene of Colombia

Betancourt D JA1, Tejada Avella ML2, Guevara AN2, Weber Scharf M1, Gómez Tapias J 2

1 *Universidad Nacional de Colombia-Sede, jabetancourtd@yahoo.com*

2 *Instituto Colombiano de Geología y Minería INGEOMINAS, Diagonal 5 No. 34-53, mtejada@ingeominas.gov.co*

The Combia Formation is a dissected volcanic complex related to the subduction of the Nazca Plate below the South American Plate in the active margin of Colombia. This unit consists on lavas and volcanoclastic deposits of late Miocene age, intruded by a series of 6 Ma andesitic porphyries, indicating an older age for Combia Formation. The geochemical analyses of these rocks showed that the lavas vary from basaltic andesites to andesites, while the porphyries are andesitic; it is also shown that in the sequence of Combia the intercalated volcanites are as much tholeiitic as they are calc-alkaline. The multi-element signature of incompatible elements indicates an origin associated to a wedge of mantle in a supra-subduction zone as suggested by the enrichment of LILE and negative anomalies of Ta, Nb and Ti. In normalized diagrams, lanthanides presents show variation in their inclination ($La_{(N)}/Yb_{(N)}$ varying between 1,8 and 8,9) the steepest ones corresponding -to the lavas as well as the porphyries- to samples that contain garnet as fenocrystals. The interpretation of this variation requires a consistent heterogeneous source in peridotite domains in the field of the plagioclases, in the case of the basaltic toleitic andesites of patterns lightly enriched in the LREE; but also of domains of garnet-bearing peridotites in the case of the cal-alkaline andesites that display the steep patterns. These conditions could be achieved if the deformation associated to a quick cortical attenuation puts in contact both domains. We consider that the volcanism is associated with cortical attenuation that started as a consequence of the modified regional stress field around a ductile accretion complex. This regime not only benefited the origin of the volcanites of Combia Formation but also of the porphyries that are distributed keeping a similar tectonic relationship.

Experimental constraints on differentiation and mixing processes in the evolution of Central Andean magma systems: Parinacota and Taapaca volcanoes

Botcharnikov RE 1, Bonecke C 1, Holtz F 1, Torresi G 1, Banaszak M2, Wörner G2

1 Inst. f. Mineralogie Universität Hannover, Callinstr. 3, 30167 Hannover, Germany
2 GZG, Abt. Geochemie, Goldschmidtstr.1, 37077 Göttingen, Germany

The compositional evolution of magmatic systems is controlled by many factors, numerous processes and prevailing conditions at depths of magma generation, storage and ascent. The most important processes responsible for the chemical variations observed in most erupted magmas are magma differentiation during crystallization and magma mixing/hybridization.

We present preliminary results of the crystallization experiments on the two magma compositions representative of the least evolved basaltic andesite magmas from Parinacota volcano and of the dacitic magmas from Taapaca volcano (N.Chile). Although both volcanoes are related to the Central Andean magma systems, the geochemical characteristics of erupted materials from these two volcanoes represent distinct magmatic regimes and processes, occurring at depth of magma generation and storage (for details see Banaszak et al., this session). The lavas of Taapaca have relatively uniform dacitic compositions over a long period of volcanic activity (ca. 1270 ka) and low eruptive rates (0.024 km^3/ka). In contrast, the rocks from Parinacota are younger (163 ka), and they have been produced in five stages of volcanic activity with eruptive rates that are at least one order of magnitude faster (0.5-1 km^3/ka) than those of Taapaca. The compositional variations cover a range from rhyolites to basaltic andesites. The major element compositions of Parinacota lavas produce continuous trends as a function of MgO and K_2O, which are typically used as differentiation indexes, indicating that magmas could be generated by differentiation and/or hybridization. Remarkably, the dacitic composition of Taapaca lies exactly on the compositional trend of Parinacota.

The experiments for natural dacite samples from Taapaca volcano have been conducted in a temperature range from 725 to 850°C, at pressures 200 and 300 MPa and at redox conditions corresponding to ca. Ni/NiO oxygen buffer (NNO) whereas experiments with natural basaltic andesite of Parinacota have been done at temperatures of 900 – 1050°C, 300 MPa and log fO_2 from NNO to NNO+1. Water activity in the system was varied using various proportions of H_2O and CO_2 in the coexisting fluid phase. The results of the experiments show that the liquid lines of descent in magmas, undergoing close-system differentiation are significantly different from the natural trends. In particular, the SiO_2 vs. MgO trend has a well-developed concave shape for the experimental residual liquids whereas bulk rock compositions of Parinacota and Taapaca lie along almost a linear trend. This discrepancy clearly indicates that the compositions of natural magmas from Parinacota are strongly affected by hybridization/mixing processes and they are presumably over-

printed by crystal fractionation processes as well. Thus, the compositions of erupted magmas represent different extent of such hybridization/differentiation processes between different end member magmas. The relatively constant composition of Taapaca lavas over a long time is presumably related to a steady-state interaction and hybridization of magmas at depths of magma stagnation. Ongoing experimental investigations are in progress to determine the volatile compositions of possible end-members and the pressures of magma storage.

The Moín High, East Costa Rica: volcanic origin or contractional structure ?

Brandes C, Winsemann J

Inst. f. Geologie, Universität Hannover, Callinstr. 30, 30167 Hannover, Germany

The back-arc area of the southern Central American arc-trench system in East Costa Rica is characterized by a complex basin system. An extensional back-arc area (the North Limón Basin) and a compressional retro-arc foreland basin (the South Limón Basin) are closely related. Both basins are separated by the Trans Isthmic Fault System. An approx. 50 km long and 30 km wide mound-shaped structure referred to as Moín High, belongs to the back-arc area. The Moín High evolved in Eocene times and has previously been suggested to be a basement structure or a paleo high. Other possible explanations for the structure are a volcanic seamount, a magmatic intrusion, a diapir, an inversion structure, a basement block or an anticline structure. A classification of the Moín High is important for a better understanding of the Costa Rican back-arc geology. Using a combination of seismic data, 3D static models and basin modelling techniques we are able to reconstruct the structure and evolution of the Moín High in detail.

The modern geothermal gradient of the North Limón Basin is 3°C/100 m. There is no evidence for a thermal anomaly or higher heat-flow in that area. A mean heat-flow of 56 – 60 mW/m^2 implies that an origin as a volcanic seamount or magmatic intrusion is unlikely. Vitrinite reflectance data indicate a normal maturity trend. A package of strong reflectors envelopes the Moín High and separates it from the surrounding and overlying sedimentary rocks. The reflector package has a constant thickness and maintains it even on the crest of the structure. Therefore this unit can be interpreted as pre-growth strata. Well data show that Upper Eocene and Oligocene deposits lack on the northern flank of the Moín High. Middle Eocene deposits are unconformably overlain by Lower Miocene rocks. The lack of Upper Eocene and Oligocene deposits can be interpreted as a response to folding, uplift and erosion. From the growth strata geometry the evolution of the Moín High can be reconstructed. Cretaceous to Lower Eocene deposits are pre-growth strata. During the Middle Eocene the first motions at the Moín High occurred. Upper Eocene units

show an onlap against the structure. In Oligocene times the uplift continued. Then deformation stopped and Lower Miocene deposits draped the structure. Slight vertical movements occurred during the Middle and Late Miocene. From the 3D static models it can be derived that the Moín High has an elliptic outline and a NNE plunging axis. This points towards a WNW-ESE directed compression.

Based on this data set it is likely that the Moín High is an anticline formed during contraction in Eocene to Oligocene times. Support for an anticline origin are the uplift and the NNE-SSW trending axis, that fit to the Eocene deformation phase of the island-arc. In addition pre-growth, growth and post growth strata can be clearly distinguished on the seismic sections. Probably the Moín High represents a pressure ridge that has been caused by transpression due to activity along the Trans Isthmic Fault System. A seamount origin can be ruled out because phases of uplift are unusual for a seamount. An origin as a magmatic intrusion is very unlikely because of the observed heat-flow and maturity. An evolution as a salt pillow/diapir can be also ruled out because of the lack of salt in the back-arc area of southern Central America.

First results of a magnetotelluric study in the Central American Isthmus

Brasse H 1, Kapinos G 1, Alvarado GE 2, Muñoz A 3, Worzewski T 4

1 Freie Universität Berlin, Fachrichtung Geophysik, Malteserstr. 74-100, 12249 Berlin, Germany, heinrich.brasse@fu-berlin.de
2 Instituto Costarricense de Electricidad (ICE), San José, Costa Rica
3 Instituto Nicaragüense de Estudios Territoriales (INETER), Managua, Nicaragua
4 IFM-Geomar, Kiel, Germany

A long-period magnetotelluric (MT) study is currently under way to investigate the deep electrical resistivity distribution at the Central American margin. As electrical resistivity is particularly sensitive to the occurrence of fluids and partial melts (if sufficiently high temperatures prevail), MT is one of the methods of choice to study fluid-involved processes in subduction zone settings.

Data were collected in 2008 along a profile in northwestern Costa Rica, extending from the coast of the Pacific Ocean via the volcanic front at Tenorio volcano to the Nicaraguan border. Period range was 10 – 10000 s, thus enabling resolution of crustal and upper mantle structures. Two types of transfer functions were determined, the impedance as the ratio of horizontal electric and magnetic fields and the tipper as the ratio of vertical to horizontal magnetic fields. Strike and dimensionality analysis reveals a basically two-dimensional (2-D) setting with the exception of the arc and the Tempisque Basin, where minor 3-D effects are observed. Preliminary 2-D inversion reveals a number of conductive anomalies (Brasse et al. 2009):

- The mafic rocks of Nicoya Peninsula are resistive, but not as much as would be expected for this type of rocks. This hints already at a certain fluid input, perhaps originating from the downgoing plate.
- A good conductor appears in the forearc at lower crustal levels. This may be associated with serpentinization, but free fluids are probably necessary to explain the high conductivities.
- Both Tempisque and San Carlos Basins are conductive, and their geometry (margins and depth extent) is well resolved.
- Beneath the arc a good conductor is modeled at shallow depths, but resolution problems due to the lack of sites exist.
- The San Carlos Basin is underlain by a poor conductor with a sharp termination in the south near Caño Negro. This may tentatively be interpreted as the trace of the Santa Elena Suture.
- Surprisingly, the mid-crust in the backarc is highly conductive. This is indicative for a large amount of free fluids or even partial melts. This anomaly is probably connected by a conductive path to the asthenospheric wedge, which itself, although not well resolved, is again modeled as a good conductor.

Data on a parallel profile are currently being collected in Nicaragua, again on a profile running from the Pacific coastline via the volcanic arc near Momotombo volcano and ending in the highlands of the Nicaraguan backarc. First results of this study and a comparison with Costa Rican data will be presented.

Reference

Brasse, H., Kapinos, G., Mütschard, L., Alvarado, G.E., Worzewski, T., and Jegen, M. (2009): Deep electrical resistivity structure of northwestern Costa Rica, Geophys. Res. Lett., doi:10.1029/2008GL036397.

Interpretation of parametric echo sounding profiles in fjords of the Magellan Region (53°S), Chile

Breuer S 1, Kilian R 1, Baeza O 1, Arz H 2

1 Universität Trier, Germany; Sonja.breuer@uni-trier.de
2 GFZ, Deutsches GeoForschungsZentrum Potsdam, Germany

The Late Glacial and Holocene sediment transport and deposition in the fjord system of the Magellan Region in the southernmost Andes at around 53°S latitude were explored by parametric echo sounding and by representative sediment cores. A major purpose was to determine regional changes in the sedimentation rates, which can be related to different denudation areas as well as to the effect of sediment transport by superficial fjord currents. Furthermore we intend to calculate sediment

volumes for selected basins and time spans.

Since the year 2002 we have obtained more than 2,500 km of seismic profiles in this area which are now analysed and interpreted. A Parametric Echo Sounding System (SES 96) from Innomar was used and operated from RV Gran Campo II. The bathymetry is calculated from the high frequency signal. To obtain an ideal penetration and high resolution for the different sediment types low frequency signals between 4 and 12 kHz were used. The pulse length ranges between 0.08 and 1 ms. and the beam width is ± 1.8°.

To determine the sedimentation rates in the echo sounding profiles, a notable characteristic of this area is that a couple of pronounced Holocene tephra layers can be traced in the profiles over hundreds of kilometres. Within the postglacial sediments e.g., a distinct highly reflective line was identified for most of the data that relates to the 4,150 cal. year BP. old tephra layer of the Mt. Burney volcano (Kilian et al. 2003, 2006).

The western part of the fjord system is situated westward of the climate divide and is affected by an annual precipitation of 3,000 to 5,000 mm (Schneider et al. 2003). Sedimentation rates deduced form from sediment cores and the echo sounding profiles are up to 12 mm/a near the partially glaciated climate divide and amount 0.1-0.3 mm/a at the westernmost island zone. The latter values are much lower than the offshore sedimentation rates of 1.4-2.7 mm/a, which were reported from the continental margin further north at around 40°S (Hebbeln et al. 2007).

In the former proglacial lake 'Seno Skyring' the sediment profiles range from the still partially glaciated and super humid Andean Cordillera over 100 km towards the subandean steppe. The sediment thicknesses range from a few cm on topographic highs to up to 40 m in basin structures. In the basins the Holocene sediment thicknesses decrease generally from west to east. The highest sedimentation rates of up to 10 mm/a occur near to the Gran Campo Nevado Ice Cap, that marks the climate divide, due to the very high Postglacial and Holocene sediment supply from the present day glaciers. In the eastern Seno Skyring the sedimentation rates are < 0.1 mm/a. Comparing the sedimentation rates in the fjords at both sides of the climate divide, the drop in sedimentation rates is much more pronounced towards the western than to the eastern fjord system. This indicates that the westerly winds hamper the westward sediment transport in superficial low salinity layers, while the eastward sediment transport is more effective, especially during a phase of strong westerlies between 12,000 and 8,500 cal. yr. BP).

In the sector of Seno Skyring with subaquatic moraine systems, the quality of the echographies is low due to strong relief fluctuations and disturbed sedimentation. The main reflector is highly reflective, continuous, and shows a chaotic-transparent internal character, which is associated to the bedrock. Moraine structures and bedrock can be separated from each other, because the moraine system features steep slopes not occurring in the bedrock.

The well-laminated continuous parallel reflectors that fill the basin depressions are interpreted as glacial sediments. These reflectors indicate a continuous, distal,

and quiet deposition of mainly clayey sediments. In several profiles, the onlapping structures at the basin margins suggest suspension fallout sediments of flocculated clay particles. The Holocene sediments often show sharp parallel reflectors with even parallel, parallel and lenticular internal patterns. They can be clearly distinguished from the Late Glacial sediment units and the moraine systems and bedrock. The Late Glacial and Holocene sediments are especially deposited in basins which were formed by glacial erosion or are overlaying the palaeosurface of the glacial sediments.

In areas with high organic content the reflectors are often transparent due to biogenic gas occurrence. In other areas along the western margin of the Cenozoic Magellanic sediment basin such transparent layers indicate gas extrusion from older and deeper sources. This is the case at the east of the Patagonian fold and thrust belt in a zone which crosses north-south of the 'Seno Skyring' and the adjacent 'Seno Otway' and where sediments of the former Magellan basin crop out. Echographies in this area show distinct pock marks, which are connected to the underlying gas bearing Cretaceous and Tertiary reservoir rocks (www.manaspetroleum.com). The sediment stratification in this area is clearly disturbed by the temporarily expulsion of gas. Some sediment layers show an acoustic blanking or transparent layers due to a high gas content within the sediments. Therefore the biogenic gas has to be differentiated from petrogenic gas ascending out of the reservoir rocks.

In the seismic profiles many debris flows or mass flows were identified at the oversteepened slopes due to their characteristic sigmoidal shape or lensoid geometry and the lacking of internal reflectors. In some cases the escarpment structures of this resedimentation features are still preserved and could have been triggered by tectonic events.

References

Hebbeln, D., Lamy, F., Mohtadi, M., Echtler, H. (2007): Tracing the impact of glacial-interglacial climate variability on erosion of the southern Andes. Geology 35/2:131-134

Kilian, R., Hohner, M., Biester, H., Wallrabe-Adams, H.J., Stern, C.R. (2003): Holocene peat and lake sediment tephra record from the southernmost Chilean Andes (53-55°S). Revista Geológica de Chile 30: 47-64

Kilian, R., Biester, H., Behrmann, J. and Baeza, O., Fesq-Martin, M., Hohner, M., Schimpf, D., Friedmann, A., Mangini, A. (2006): Millennium-scale volcanic impact on a superhumid and pristine ecosystem. Geology 34: 609-612

Schneider, C., Glaser, M., Kilian, R., Santana, A., Butorovic, N., Casassa, G. (2003): Weather observations across the Southern Andes at 53°S. Physical Geography 24/2: 97-119.
http://www.manaspetroleum.com/s/Chile.asp?ReportID=296679

Estimation of Holocene denudation rates for non-glaciated areas of the super humid southernmost Andes (53°S), Chile

Breuer S 1, Kilian R 1, Baeza O 1, Lamy F 2

1 Universität Trier, Germany; Sonja.breuer@uni-trier.de
2 AWI, Alfred-Wegener-Institut für Polar- und Meeresforschung Bremerhaven, Germany

Long-term Cenozoic average denudation rates of up to 1,000 mm/ka (Thomson 2002) have been estimated for the southernmost Andes based on fission track analyses. These rates represent averages over longer time periods and for more extended areas. They combine the effect of different climate phases, the variations in extent of glacial erosion as well as the regional distinct morphologies and different kind of exposed rocks and/or vegetation cover. Therefore we try to determine Holocene denudation rates for areas with recorded and well-defined climate, morphology and vegetation cover which was constrained by remote sensing data. To calculate the denudation rates, we computed sediment masses of Late Glacial and Holocene lakes, which have been determined by sediment drilling and echo sounding. We selected lake system for which a nearly closed system of denudation and deposition can be assumed.

The three selected lakes are spanning a transect across the Andes from west to east of the Gran Campo Nevado Ice field. All examined lakes have no or very small tributaries and are primarily fed by rain and/or melt water.

The westernmost lake Tamar is located on the Tamar Island in the western part of the Magellan Strait. In this area annual precipitation is about 4,000 mm and the vegetation is dominated by Magellanic moorland type and partially by Magellanic rain forest. The surrounding slopes reach an elevation of 400 m and are up to 60° steep. Lake sediment cores show that several mud flows moved downhill into the lake during the extremely humid Early Holocene. The calculated denudation rate for this catchment is about 3.6 mm/ka, which represents a minimum value, since the postglacial weathering horizon is only partly removed into the lake. Exceptionally high Fe/Ti ratios and Fe hydroxide precipitation in the lake sediments and the surrounding fjord sediments indicate that chemical denudation is also very important.

The Muy Profundo Lake (unofficial name) is located at 500 m a.s.l. and the denudation area includes a nearly vegetation-free zone up to 750 m a.s.l. within the Patagonian Batholith. The precipitation ranges from 5,000 to 8,000 mm/year (Schneider et al. 2003). The denudation rates of the catchment amount to 0.42 mm/ka. Despite of the high precipitation this denudation rate is unexpectedly low. The catchment area of Muy Profundo Lake is characterised by a roche moutonnée landform with steep slopes and active fracture zones. The striations of past glaciations still have remained on the rock surfaces since at least 14,000 cal yr. BP when glaciers disappeared from the catchment. Along the active fractures a stronger denudation is obvious, resulting in restricted gullies. The removed predominantly coarsely clastic material is stored in alluvial cones and is not transferred into the lake bottom

which was considered for the mass balance calculation. The sediment input into the lake bottom mainly consists of clay and silt. Comparable denudation rates of 0.2 to 1.0 mm/ka have been calculated for a roche moutonnée landform in the Riksgränsen area in northern Norway (Dixon et al. 2002; André 1995).

The easternmost lake Chandler is located in a denudation area with moderate relief, a maximum elevation of 200 m a.s.l. and relatively flat slope angels. Within the vegetation cover, that consists mainly of Magellanic rainforest and peat land, roches mountonnées crop out occasionally. The precipitation varies from 3,500 to 5,000 mm/year. The calculated denudation rates for different Holocene periods are between 0.4 and 1.3 mm/ka. Comparable to that of the Tamar Lake, the Chandler region is also characterised by an intense chemical denudation. At the interface between peaty soil and the bedrock acid soil water (pH 3-4) has formed a 10-20 cm thick weathering horizon which mainly consists of clay and gravels. Heavy metals like Fe, Pb and Mn are selectively leached out from this horizon and are partly precipitated as iron hydroxides in the lake or in the surrounding fjord system. If the postglacial weathering horizon is only partially removed (<10%) and supplied to the lake, the calculated denudation rates represent only minimum values for bedrock denudation which we estimate to be up to 10 times higher compared to our calculated values. Chemical denudation rates from SW-Iceland amounts to 33.1 mm/ka (Gislason et al. 1990). Owen et al. (2007) delineate chemical weathering rates on gneiss surfaces in Norway between 1.63 and 3.61 mm/ka.

On the basis of these first preliminary calculations, we conclude that chemical weathering and chemical denudation are important in areas with vegetation cover in the superhumid Andes. They may become even more important, if the slopes become flatter and the soils become permanently water filled. In a long-term perspective, the relatively high denudation rates of low elevated peat land compared to the exposed rock surfaces may further increase the relief even during interglacial periods, like the Holocene. This situation is the reverse of what is typically expected for mountain ranges without extended glacier or river systems. The extreme high precipitation is only a subordinate control mechanism concerning the denudation in ice-free areas of the southernmost Andes. Compared to long term denudation rates (fission track rates) our values are 99 % lower, thus confirm the overall dominant denudation control by temperate glaciers.

References

André, M.F. (1995): Post-glacial microweathering of granite roches moutonnées in northern Scandinavia (Riksgräsen area 68°N). In: Slaymaker, O. (ed.): Steepland geomorphology. John Wiley & Sons

Dixon, J.C., Thorn, C.E., Darmody, R.G., Campbell, S.W. (2002): Post-glacial rock weathering processes on a roche moutonnée in the Riksgränsen area (68°N), northern Norway. Norsk Geografisk Tidsskrift - Norwegian Journal of Geography 56: 257-264

Gislason, S.R., Arnorsson, S., Armannsson, H. (1990): Chemical denudation rates in SW-Iceland. Chemical Geology 84: 64-67

Owen, G., Matthews, J.A., Albert, P.G. (2007): Rates of Holocene chemical weathering, 'Little Ice Age' glacial erosion and implications for Schmidt-hammer dating at a glacier-foreland boundary, Fåbergstølsbreen, southern Norway. The Holocene 17/6: 829-834

Schneider, C., Glaser, M., Kilian, R., Santana, A., Butorovic, N., Casassa, G. (2003): Weather observations across the Southern Andes at 53°S. Physical Geography 24/2: 97-119.

Thomson, S.N. (2002): Late Cenozoic geomorphic and tectonic evolution of the Patagonian Andes between latitudes 42°S and 46°S: An appraisal based on fission-track results from the transpressional intra-arc Liquiñe-Ofqui fault zone. GSA Bulletin 114/9: 1159-1173

Paleogeographic boundary in the evolution of the Pucara Basin (Triassic-Liassic) and the Arequipa basin (Lias-Dogger): an inheritance of the block accreted during the Mesoproterozoic

Carlotto V 1, 2, Cardenas J 2, Cano V 2, Rodriguez R 1

1 INGEMMET, Av. Canadá 1470 San Borja, Lima, vcarloto@ingemmet.gob.pe
2 Universidad Nacional San Antonio Abad del Cusco UNSAAC

Regional studies recently carried out in the Totos and Paras region (Ayacucho), in the center of Peru, reveal the evidence of a regional system of E-W reverse faults named Abancay-Andahuaylas-Totos (A-A-T). This system defines the southern border of a Mesozoic structural high (Totos-Paras High), whereas the Cusco-Lagunillas-Mañazo (C-L-M) fault system defines the southern border of the Cusco-Puno High. In both cases, the A-A-T fault system and the Totos-Paras structural high are a prolongation of the C-L-M fault system and the Cusco-Puno High respectively. The northern boundary of the Puno-Cusco High is the Urcos-Sicuani-Ayaviri fault system, while the northern limit of the Totos-Paras High is covered by Cenozoic volcanic rocks. During the Mesozoic, the A-A-T and C-L-M fault systems, respectively dipping south and southwest, played as normal faults, separating the western (Arequipa) basin from the Totos-Paras and Cusco-Puno highs. It was controlling the marine and continental sedimentation, with higher thickness in the basin and lower thickness on the structural high. During the Cenozoic, these faults had several movements, first strike-slip and later reverse, rising up the NE edge of the former basin and filling in the old high, which behaved as a continental foreland basin. The NE-vergent foreland front is the C-L-M fault systems, which shows the greatest deformation and shortening (Carlotto, 1998). However, this fault shows an East-West strike in the NW, where it is called Abancay-Andahuaylas-Totos fault, whose

prolongation to the coast coincides with the boundary between the Arequipa and Paracas blocks (Ramos, 2008).

In the Totos-Paras area, the Chunumayo Formation of Toarcian-Bajocian age is 200-500 m thick and overlies volcanic rocks of the Permo-Triassic Mitu Group. Above of the Chunumayo Formation are 300 m of the Yura Group (Middle-Upper Jurassic) corresponding to a fluvial-deltaic environment. In contrast, to the south, in the Arequipa basin, these deposits have thicknesses greater than 2000 m, with deeper environments going from turbidite to slope and shelf deposits. Both in the high area and in the basin, the sequence ends with the Ferrobamba or Arcurquina (Albian-Turonian) limestones, deposited in restricted platform environments, and thinner in the high area (50 m) than in the basin area (600 m).

The A-A-T fault system strikes East-West, behaves as reverse faults and shows 5 thrust sheets. The thickness of the Jurassic-Cretaceous units increase to the south, from one sheet to another. Together with the presence of olistoliths and synsedimentary normal faults, these faults may be interpreted as older normal faults dipping to the south, and which have controlled the sedimentation of the Chunumayo Formation and Yura Group. Further in the north, at the core of the Mitu (Permo-Triassic) outcrops, the faults have controlled the structural high. These faults behaved as normal faults from approximately Toarcian to Turonian times, separating the Totos-Paras High in the Arequipa basin and controlling sedimentation and olistolith development. In the paleogeographic context, the Abancay-Andahuaylas-Totos (A-A-T) fault system is an extension of the Cusco-Lagunillas-Mañazo (C-L-M) system, also parallel to de southern edge of the Cusco-Puno High and separaing the Arequipa basin during the Jurassic and Cretaceous.

Paleogeographic studies in the Norian-Pliensbachian limestones of the Pucara Group (Chambara, Aramachay and Condorsinga Fms) show that the Pucara basin developed mainly in central and northern of Peru. Norian transgression (Chambara Formation, Norian-Rhaetian) reached the Totos-Paras area, but not the south, where there is no record. In the Totos-Paras High, the Chunumayo Formation (Toarcian-Bajocian) directly overlies Permian-Triassic units, with no Pucara Group, and in the south, in the Arequipa basin, the Chocolate Formation (Sinemurian) directly overlies the Proterozoic substrate.

The Sinemurian-Pliensbachian transgressions (Aramachay and Condorsinga formations) reached the structural high of Totos-Paras and extended toward the south, to the Arequipa basin, where the deposits are known as Lagunillas Formation (Hettangian-Sinemurian) and Chocolate Formation (Sinemurian).

The C-L-M fault system is the boundary between the Cusco-Puno High and the Arequipa basin, located to the south, while to the north, the U-S-A fault system is the boundary with the Peruvian south eastern basin. This paleogeography developed during the Jurassic-Cretaceous. Furthermore, the Totos-Paras high is the extension of the Cusco-Puno High, separated from the Arequipa basin to the south by the A-A-T system, and with Pucara basin to the north. In addition, the Cusco-Puno structural high, currently corresponding to the Western Altiplano, in the north is separa-

ted from the Eastern Altiplano or southern edge of the Eastern Cordillera by the U-S-A fault system, and in the south, from the northern edge of the Western Cordillera by the C-L-M fault system. In this region, mineralogical, geochemical, isotopic and geochronological data allow to distinguish three associations of potassic (P) and ultrapotassic (UP) rocks (Carlier et al., 2005). The first group, mostly composed of Oligocene lamproites with phlogopite in the Eastern Altiplano, demonstrates the presence of a Paleoproterozoic to Archaic (TDM = 1130-2485 Ma; εNd = -5.0 to –11.4; $^{87}Sr/^{86}Sr_i$ = 0.7100-0.7159) metasomatized harzburgite mantle beneath this domain. Beneath the Western Altiplano, the deep lithosphere corresponds to a younger (TDM = 837-1259 Ma; εNd = +0.6 to –6.3; $^{87}Sr/^{86}Sr_i$ = 0.7048-0.7069) metasomatized lherzolithic mantle, as indicated by a second group of Oligocene and Miocene P-UP diopside-rich lavas (leucitites, tephrites with leucite, traquibasalt with olivine and diopside). A more recent (< 2 Ma) third group crops out at the boundary between both Altiplano domains and is composed of lamproites with phlogopite and diopside, kersantites, minettes and augite trachybasalts, showing a mantle source which probably includes an astenospheric component, apart from material derived from the two lithospheric mantles previously described (TDM= 612-864 Ma; εNd = -1.1 to -3.5; $^{87}Sr/^{86}Sr_i$ =0.7051-0.7062). This third group, present as volcanic edifices, dikes, stocks, domes, etc., is located over the still active fault system of the U-S-A or Cusco-Vilcanota, and marks the boundary between both parts of the Altiplano.

Summarizing, the older Cusco-Puno High has a deeper metasomized lerzholithic mantle lithosphere below the Western Altiplano. This block is separated from the Western Cordillera by the C-L-M fault system. Beneath the Eastern Altiplano, corresponds to a Paleoproterozoic to Archaic metasomatized harzburgite mantle. This is added to the presence of the Arequipa Massif (with ages between 1900 and 600 Ma) which is the basement of the Western Cordillera (oldest Arequipa basin). Hence, the lithosphere of the western margin of the South American continent is a mosaic of amalgamated lithospheric blocks (terranes) accreted to Amazonia during the Sunsás orogeny at 1000 Ma. This was a complex collision between a large block, the Arequipa Massif, and other small lithospheric blocks which later formed the substrate for the Western and Eastern Altiplano. If we consider the Totos-Paras High as a prolongation of the Cusco-Puno High, then the substrate would be the same which comes from Cusco-Puno High. This study shows how the older structures control not only Meso-Cenozoic paleogeography, but also Andean deformation.

References

Carlier G, Lorand JP, Liégeois J, Fornari M, Soler P, Carlotto V, Cardenas J (2005) Potassic ultrapotassic mafic rocks delineate two lithospheric mantle blocks beneath the southern Peruvian Altiplano. Geology, 33 601-604.

Carlotto V (1998) Evolution andine et raccourcissement au niveau de Cusco (13°-16°S, Pérou). These Université de Grenoble, France 159 p.

Ramos V (2008) The Basement of the Central Andes: The Arequipa and related Terranes, Annual Review of Earth and Planetary Sciences 36: in press.

Spatial and Temporary Dynamics of Land Cover and Land Use in the Natural Reserve of Apoyo Lagoon, Nicaragua - 1972 to 2007

Castellón A1, Bonilla G1, Acosta N2, Meyrat S3, Espinales E1, Martínez O1

1 Instituto Nicaragüense de Estudios Territoriales, Managua, Nicaragua, casteyrat@hotmail.com
2 Bundesanstalt für Geowissenschaften und Rohstoffe, Project on the Mitigation of Georisks in Central America, Managua, Nicaragua
3 AMICTLAN, Catarina, Nicaragua

With a diameter of 6 km, the Apoyo Lagoon is the biggest lagoon of volcanic origin in Nicaragua. Due to its cristalline waters and a beautiful landscape is one of the most visited places in the country. It was declared Natural Reserve in 1991. The territory of the lagoon is administered by six municipalities (Catarina, Diriá, Diriomo, Granada, Masaya y San Juan de Oriente). The enviromental conservation is a priority to the municipalities but agriculture activities, deforestation, and an accelerated incrementation of the population are some factors that put in risk the preservation of this lagoon. AMICTLAN is the association of municipalities which was founded, in 2005, to preserve the Apoyo Lagoon Natural Reserve.

It receives technical and financial support by "Geólogos del Mundo" (World Geologists) and the government of Catalunya. Since 2005, several environmental studies have been executed for the area. In 2006, it was decided to carry out a study of dynamic of land cover and land use to know the influence of the human activities in the enviroment. Supported by the use of ortophotos, topographic maps, GIS technologies and field visits it was possible to evaluate the changes from 1972 till 2007.

A multidisciplinary project on cordilleran batholiths in Argentina : New data and perspectives

Castro A 1, Fernández C 2, Moreno-Ventas I 1, Gallastegui G 3, Corretgé LG 4, Vujovich, G 5, Martino, R 6, Becchio, R 7, Otamendi, JE 8, Heredia, N 3, Gerya, T 9

1 Dept. de Geología, Universidad de Huelva, E-21071 Huelva, Spain
2 Dept. de Geodinámica y Paleontología, Universidad de Huelva, E21071-Huelva, Spain
3 Instituto Geológico y Minero de España, Matemático Pedrayes 25, E-33005 Oviedo, Spain
4 Dept. de Geología, Universidad de Oviedo, E-33005 Oviedo, Spain
5 Dept. de Geología, Univ. de Buenos Aires, 1428 Buenos Aires, Argentina
6 Dept. de Geología, Universidad Nacional de Córdoba, Córdoba, Argentina
7 CONICET, Instituto Geonorte, Facultad de Ciencias Naturales, Universidad Nacional de Salta, 4400 Salta, Argentina
8 Dept. de Geología, Universidad Nacional de Río Cuarto, Río Cuarto, Argentina
9 Dept. of Earth Sciences, ETH Zurich, Clausiusstrasse 25, CH-8092 Zurich, Switzerland

A new multidisciplinary project founded by the Spanish Ministry of Education and Science is being developed on the cordilleran-type Patagonia batholith (2100 km long) in Argentina since 2007. The Patagonia Cordilleran batholith (Gordon and Ort, 1993) is located in the northern part of Patagonia batholith, occupying the axis of the north- Patagonian Andes between 38° and 46°S latitude (900 km aprox.). Although the project is focused on the petrogenesis and emplacement of granitoids of the North Patagonia Cordilleran batholith of Cretaceous age, other older and younger batholithic intrusions are also studied for comparative purposes in the region. These include the Jurassic Subcordilleran batholith and Tertiary plutons that in many cases overlap the area of the Cretaceous batholith. Also included are the older, Paleozoic granite intrusions from the Famatinian magmatic arc (Otamendi et al., 2008, Castro et al., 2008) in San Juan province.

One of the main objectives of this project is to test models for granodiorite magma generation, either within the continental crust or within the suprasubduction mantle wedge. The classical view of a pure crustal origin entails many problems and disagreement with thermal models for the continental crust, even if this is anomalously heated from an upwelling mantle. In contrast, recently developed concept suggesting sub-lithospheric melting of subducted tectonic melanges rising from the slab in form of large positively buoyant diapirs/plumes (Gerya and Yuen, 2003) provides a new consistent scenario for the generation of cordilleran batholiths (Castro and Gerya, 2008). The North Patagonia batholith has been chosen to test these new models as it is related unambiguously to an active continental margin. A comprehensive knowledge of the geochemistry of the rocks and the timing of emplacement in relation to tectonic processes is required to test model predictions. In this way, a SHRIMP-based study of zircons is being developed for these granitoids. Petrogenesis is also modelled by the use of high-pressure experiments that simulate conditions in the suprasubduction mantle wedge and produce constraints to the thermal requirements for magma generation.

The first results from the study of the Cretaceous granitoids in Argentina come from the area of Bariloche, from latitude 40°35' to 41°35' S, from the area of Río Manso to Lago Traful. Two plutonic domains have been identified in this sector. The south domain, characterized for the association diorite-quartzdiorite-granodiorite; and the north domain, characterized by the predominance of biotite granites and granodiorites. Theseplutonic rocks were emplaced into slightly younger Jurassic volcanic and sedimentary rocks, at low depths and profiting extensional or transtensional structures (Giacosa and Heredia, 2004). Considered jointly, all the Cretaceous plutonic rocks of the region display a typical calc-alkaline trend with identical features to the paradigmatic cordilleran batholiths of North America (Sierra Nevada and Peninsular Ranges). In detail, the relations are complex and a single geochemical trend related to differentiation from a common mafic magma cannot be traced. The more basic rocks are diorites (SiO_2 49.6-57.7 wt%), well represented at the margins of the south domain (The Rio Manso intrusion). These form a coherent geochemical group characterized by almost flat REE patterns, with Ce_N/Lu_N

ratios of 0.06–7.05 and LuN from 7.3-17.8. By contrast, quartzdiorites, granodiorites and granites display more fractionated trends with strong internal similarities denoting a common process of genertion. These patterns suggest that this common process was possibly dominated by variable melting rates from a common source. The alternative, equilibrium differentiation from a parental magma, cannot be discarded at this stage. The more basic rocks (diorites) are possibly derived from a metasomatized mantle source rich in incompatible elements (K, Ba, REE, etc.). Our experimental results and comparisons with other arc rocks, suggest that these magmas were not in equilibrium with olivine in the source (Low Mg# from 0.38-0.55 and low Ni contents, Ni <50 ppm). For the volumetrically dominant and more silicic group defined by the quartzdiorite-granodiorite-granite association, a mantle source is very unlike. These rocks are the main objective of this project. The results from new experimental studies carried out in the Huelva laboratory, indicate that temperatures of the order of 1100 °C at pressures of 1.5 to 2.0 GPa are required to generate liquids of granodiorite composition that satisfy the geochemical features of calc-alkaline batholiths. These high T are very unlike in the continental crust. Thus, the idea of a direct implication of the mantle wedge in granitoid generation is more plausible according to our data. The new results from the study of the North Patagonia batholith may serve to test these results with a natural example. The emplacement of this batholith in an extensional or transtensional regime is also in favour with the participation of mantle-wedge plumes in the generation of silicic and basic magmas.

References

Castro, A., Gerya, T. (2008) Magmatic implications of mantle wedge plumes: experimental study. Lithos doi:10.1016/j.lithos.2007.09.012.

Castro, A., Martino, R., Vujovich, G., Otamendi, J., Pinotti, L., D'eramo, F., Tibaldi, A., Viña, A. (2008) Top-down structures of mafic enclaves within the Valle Fértil magmatic complex (Early Ordovician, San Juan, Argentina). Geologica Acta 6, 217-229.

Gerya, T., Yuen, D.A. (2003) Rayleigh-Taylor instabilities from hydration and melting propel "cold plumes" at subduction zones. Earth Planet Sci Lett 212, 47-62.

Giacosa, R.E., Heredia, N. (2004) Structure of the North Patagonian thick-skinned fold-and-thrust belt, southern central Andes, Argentina (41º-42ºS). Journal of South American Earth Sciences 18, 61-72.

Gordon, A. y Ort, M. (1993).- Edad y correlación del plutonismo cordillerano en las provincias de Rí o Negro y Chubut. In: Actas del XII Congreso Geológico Argentino 4, 120-127.

Otamendi, J.E., Tibaldi, A.M., Vujovich, G.I., Viñao, G.A. (2008) Metamorphic evolution of migmatites from the deep Famatinian arc crust exposed in SierrasValle Fértil-La Huerta, San Juan, Argentina. J South Am Earth Sciences 25, 313-335.

Análisis geológico estructural para la determinación de riesgos geológicos en el sureste del área metropolitana de Monterrey (Cañón el Huajuco, La Estanzuela), Nuevo León, México

Chapa-Guerrero JR, Chapa Arce RI, García Puente DM, Lemus Alarcón OR, Garza Vela LA, Méndez DS, Ibarra Martínez SE

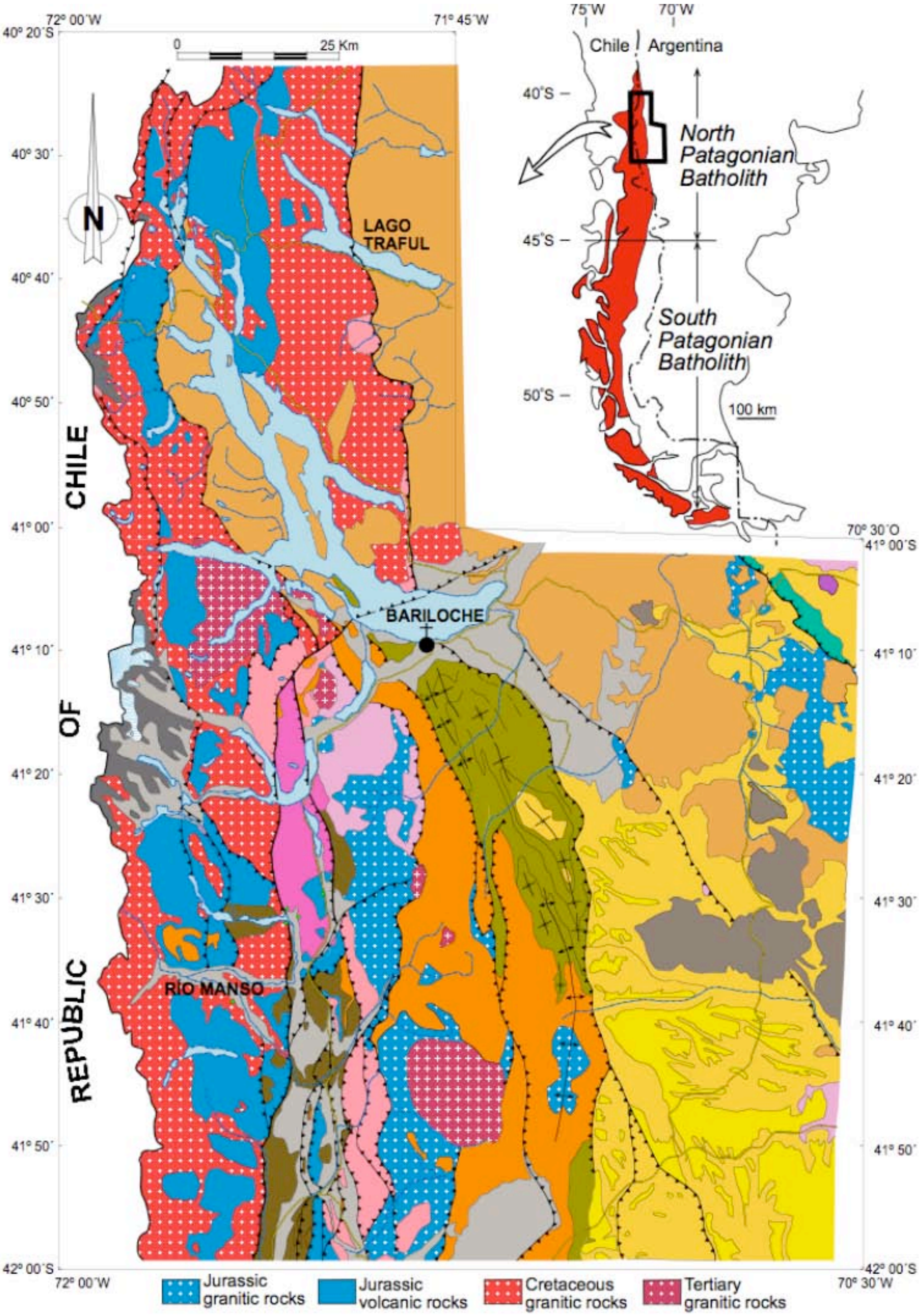
Facultad de Ciencias de la Tierra, Universidad Autónoma de Nuevo León rchapa@fct.uanl.mx

En las últimas décadas, el área metropolitana de Monterrey ha experimentado un gran crecimiento demográfico a causa de que es una de las ciudades más importantes del noreste de México. El antiguo patrón de crecimiento caracterizado por la concentración de la población en grandes ciudades hace que Monterrey sea la tercera ciudad más grande del país, contando con una población de 4 millones de habitantes. Por otro lado a falta de vivienda la ciudad se ha expandido de forma desorganizada hacia zonas vulnerables a la ocurrencia de desastres sobre las laderas naturales de la Sierra Madre Oriental.

En estas zonas se han presentado diversos problemas de ingeniería, tales como: inestabilidad de taludes, el bloqueo de los cauces de corrientes superficiales por construcción de obras civiles, extracción de material en canteras aplicando métodos inadecuados, entre otros. A pesar de los avances en el conocimiento técnico y científico de los procesos geológicos que ocurren en el área de estudio o en zonas urbanas análogas, muchas zonas son aún vulnerables a situaciones de desastre.

El área de estudio, ubicada geográficamente en la región SE del Área Metropolitana de Monterrey, y geológicamente entre el frente noreste del anticlinal de los Muertos y el Cerro de la Silla, se puede considerar entre las zonas con mayor riesgo a movimientos de ladera por presentar impacto de urbanización en montaña. Geológicamente hablando, el área de estudio se constituye de Lutitas del Cretácico Superior y material del cuaternario.

La metodología que se aplica para la elaboración del estudio en el cañón el Huajuco consta de una clasificación de zonas geológicas homogéneas y zonas de pendientes, las cuales posteriormente se traslapan para determinar zonas de riesgos geológicos. Por otro lado, se analizan los efectos estructurales de la curvatura de Monterrey en la estabilidad de taludes existentes para determinar las zonas sujetas a movimientos en masa tanto de taludes naturales y artificiales, evaluando los problemas geotécnicos del área para determinar las diferentes zonas de riesgo. A si mismo, se aplican métodos geofísicos para corroborar los aspectos geológicos del área de estudio.


72° 00´W
71° 45´W
40° 20´S
0
25 Km
40° 30´
40° 40´
40° 50´
41° 00´
41° 10´
41° 20´
41° 30´
41° 40´
41° 50´
42° 00´S
72° 00´W
N
LAGO TRAFUL
CHILE
OF
REPUBLIC
BARILOCHE
RÍO MANSO
70° 30´O
41° 00´S
41° 10´
41° 20´
41° 30´
41° 40´
41° 50´
42° 00´S
70° 30´W
75°W
70°W
Chile
Argentina
40°S
45°S
50°S
North Patagonian Batholith
South Patagonian Batholith
100 km
Jurassic granitic rocks
Jurassic volcanic rocks
Cretaceous granitic rocks
Tertiary granitic rocks

The southernmost segment of the suture between Pampia terrane and the Rio de la Plata craton, La Pampa province, Argentina: constraints from zircon U-Pb SHRIMP dating and Hf isotopic data

Chernicoff CJ 1, Zappettini EO 2, Santos JOS 3, McNaughton NJ 3

1 Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)
2 Servicio Geológico-Minero Argentino
3 University of Western Australia - Redstone Resources jchern@secind.mecon.gov.ar

The Neoproterozoic-Cambrian basement of the southern-central La Pampa province, Argentina, originally regarded to pertain to a single stratigraphic unit irrespective of terrane boundaries (Las Piedras Complex; Tickyj et al., 1999), actually comprises the southernmost portions of the Pampia terrane (PT) and the Río de La Plata craton (RPC), as established by Chernicoff and Zappettini (2003a, 2003b; 2004) on the basis of aeromagnetic data and very limited exposures. These data have permitted the latter authors to identify lithologic, genetic, structural and geochronological differences between either block. The suture zone trends roughly north-south and dips to the west.

Zappettini et al. (2009) have recently proposed the term Las Piedras Formation for the (metasedimentary) basement rocks lying on the RPC (eastern) side of the boundary (see also Chernicoff *et al.* 2006, 2007, 2008c), and Paso del Bote and Valle Daza Formations for the (metaigneous) basement rocks lying on the PT (western) side of the boundary (see also Chernicoff *et al.*, 2005, 2008d, 2008e, 2008f, 2009; Villar et al., 2005; Zappettini *et al.*, 2005).

We regard the RPC to have originally encompass a Paleoproterozoic (to Archean) nucleous and an outer Mesoproterozoic belt (as it is the case for other cratonic blocks, e.g. Amazonas, Kalahari and Congo). This belt would have been later detached from the RPC nucleous (sometime prior to 600 Ma), and finally re-accreted during the Neoproterozoic to Cambrian (see also Zappettini et al., 2009). The latter collisional event originated the Pampean orogen. In this work we focus on the southernmost segment of the PT / RPC suture. This suture zone comprises Cambrian metaigneous rocks originated on the PT side (upper plate) of the suture.

We present zircon U-Pb SHRIMP and Hf isotopic data as well as geochemical data of metaigneous rocks associated with this portion of the PT/RPC suture. The latter rocks are metadiorites with arc geochemical signature and metapiroxenites with MORB geochemical signature; both rock types are imbricated in the suture zone. U-Pb SHRIMP zircon dating of the metadiorites yielded 519.5±1.4 Ma, and U-Pb SHRIMP zircon dating of the metapiroxenites yielded 521.2±7.7Ma.
Hf isotopic data of the dated zircons of the metadiorite show negative εHf values, indicating a dominant crustal component in the melt which generated the zircons. The age of such crustal source ranges 1000 to 1400 Ma (yielded Hf T*DM* model ages), reinforcing previous data that indicate a Mesoproterozoic age for the substratum of the Pampia terrane.

References

Chernicoff, C.J. and Zappettini, E., 2003a. Evidencias geofísicas para la delimitación de terrenos pregondwánicos en la región centro-austral argentina. 10 Congreso Geológico Chileno. Digital Proceedings.

Chernicoff, C.J. and Zappettini, E.O., 2003b. Delimitación de los terrenos tectonoestratigráficos de la región centro-austral argentina: evidencias aeromagnéticas. Revista Geológica de Chile, 30 (2): 299-316.

Chernicoff, C.J. and Zappettini, E., 2004. Geophysical evidence for terrane boundaries in south-central Argentina. Gondwana Research. 8 (4): 1105-1116.

Chernicoff, C.J. and Zappettini, E.O., 2005. Identification of the southernmost Paganzo basin deposits (Upper Paleozoic red beds) in south-central Argentina. Gondwana 12 Conference. Mendoza. Proceedings: p. 102.

Chernicoff, C.J. and Zappettini, E.O., 2007. La cuenca paleozoica de Arizona, sudeste de San Luis, Argentina: extensión austral de la cuenca de Paganzo. Revista de la Asociación Geológica Argentina, 62 (2): 321-324.

Chernicoff, C.J., Zappettini, E.O and Villar, M.L., 2005. La faja de metagabros del sector centro-norte de la provincia de La Pampa, Argentina: nuevas evidencias geofísicas. 16 Congreso Geológico Argentino, Proceedings: 39-44.

Chernicoff, C.J., Santos, J. O.S., Zappettini, E.O. and McNaughton, N. J., 2006. Identification and zircon U-Pb SHRIMP dating of the Green quarry schists, southern San Luis province, Argentina. 5 South American Symposium on Isotope Geology, Proceedings: 77-79.

Chernicoff, C.J., Santos, J. O.S., Zappettini, E.O. and McNaughton, N. J., 2007. Esquistos del Paleozoico Inferior en la cantera Green, sur de San Luis, Argentina: edades U-Pb SHRIMP e implicancias geodinámicas. Revista de la Asociación Geológica Argentina, 62 (1): 154-158.

Chernicoff, C.J., Santos, J. O.S., Zappettini, E.O., Villar, L.M. and McNaughton, N. J., 2008a. U-Pb SHRIMP dating of the Famatinian (Lower Paleozoic) metamorphism in La Pampa province, Argentina. VI South American Symposium on Isotope Geology, Digital Proceedings.

Chernicoff, C.J., Santos, J. O.S., Zappettini, E.O. and McNaughton, N. J., 2008b. Edad U-Pb SHRIMP del metamorfismo famatiniano en la provincia de La Pampa. 17 Congreso Geológico Argentino, Proceedings: 9-10.

Chernicoff, C.J., Santos, J. O.S., Zappettini, E.O., Villar, L.M. and McNaughton, N. J., 2008c. Zircon U-Pb SHRIMP dating of the Lower Paleozoic paraschists at Sierra de Lonco Vaca, La Pampa province, Argentina. VI South American Symposium on Isotope Geology, Digital Proceedings.

Chernicoff, C.J., Zappettini, E.O., Santos, J. O.S., Villar, L.M., and McNaughton, N. J., 2008d. El arco magmático famatiniano en la provincia de La Pampa. 17 Congreso Geológico Argentino, Proceedings: 11-12.

Chernicoff, C.J., Santos, J. O.S., Zappettini, E.O., Villar, L.M. and McNaughton, N. J., 2008e. Zircon U-Pb SHRIMP dating of the Lower Paleozoic La Pampa belt of

metagabbros, Argentina. VI South American Symposium on Isotope Geology, Digital Proceedings.

Chernicoff, C.J., Zappettini, E.O., Villar, L.M., Chemale, F. and Hernández, L., 2008f. The belt of metagabbros of La Pampa: Lower Paleozoic back-arc magmatism in south-central Argentina. Journal of South American Earth Sciences, Special Issue "Mafic and Ultramafic complexes in South America and the Caribbean. (in press).

Chernicoff, C.J., Zappettini, E.O., Santos, J. O.S, Beyer, E. and McNaughton, N. J., 2008g. Foreland basin deposits associated with Cuyania terrane accretion in La Pampa province, Argentina. Gondwana Research, 13 (2): 189-203.

Chernicoff, C.J., Zappettini, E.O., Santos, J.O.S., Allchurch, S. and McNaughton, N.J., 2009. The southern segment of the Famatinian magmatic arc, La Pampa province, Argentina. Gondwana Research (submitted).

Tickyj H, Llambías EJ, Sato AM, 1999. El basamento cristalino de la región sur-oriental de la provincia de La Pampa: Extensión austral del Orógeno Famatiniano de Sierras Pampeanas. Actas 14 Congreso Geológico Argentino, 1: 160-163, Salta.

Zappettini, E.O., Chernicoff, C.J., Santos, J.O.S., McNaugton, 2009. Los esquistos neoproterozoicos de Santa Helena, provincia de La Pampa, Argentina: edades U-Pb SHRIMP, composición isotópica de Hf e implicancias geodinámicas. Revista de la Asociación Geológica Argentina (in press).

Implications of detrital isotopic data from Cambro-Ordovician metasediments of the Famatina belt (Central Andes) in the Late Neoproterozoic-Early Paleozoic evolution of Western Gondwana

Collo G, Astini RA

Laboratorio de Análisis de Cuencas, CICTERRA-Universidad Nacional de Córdoba, Argentina. gcollo@efn.uncor.edu, raastini@efn.uncor.edu

The Famatina belt, located in the Argentine foreland, has been interpreted as part of an accretionary margin built along the western Gondwana during the early Paleozoic. Its low-grade metasedimentary rocks comprise a siliciclastic-volcaniclastic Upper Cambrian-Middle Ordovician succession, that experienced a complex post-depositional history related to the Ordovician Ocloyic Orogeny. Detrital zircon data (U-Pb SHRIMP) of sandstones from the Achavil and Negro Peinado formations allow interpreting Gondwanan sources, which assisted to analyze the early stages of the Proto-Andes in this region (Collo et al. 2009). The sample from the Achavil Formation has two main populations at 521 ± 6 Ma (n=8) and 630 ± 9 Ma (n=26), and some subordinated ages (ca. 781, 1038, 1118, 1322, 1908 and 2096 Ma). The sample of the Negro Peinado Formation has four main populations at 522 ± 4 Ma (n=12); 638 ±16 Ma (n=8); 997 ±20 Ma (n=14) and 1220 ± 25 Ma (n=17), and

subordinated ages (ca. 732, 1496 and 1690 Ma). CL images suggest their derivation from largely igneous sources with the youngest ages approximating the time of sediment accumulation. The Negro Peinado Formation is not older than Middle Cambrian (youngest grain at ca. 505 Ma.), while a slightly younger depositional age can be established for the Achavil Formation (youngest grain at ca. 490 Ma). A younger age for the last unit is also consistent with the regional trend from pre- to post-Pampean units in the southern area of the Central Andean segment (Schwartz and Gromet, 2004; Steenken et al., 2006; Rapela et al., 2007), which essentially show a progressive decrease of Mesoproterozoic grains and increasing of the Neoproterozoic ages. Disregarding the Cambrian (Pampean) input, similarities between Negro Peinado Formation and the older Ancasti Formation (located further east of the study region) and between Achavil Formation and the younger La Cébila Formation are sticking. This trend, in which typical Brasiliano and Grenville populations persist through the post-Pampean units, was also suggested by Adams et al. (2008) to the north based in detrital zircon populations analyzed in the Puncoviscana Formation and the overlying Mesón Group.

eNd(500) and T_{DM} values from samples of Negro Peinado and Achavil formations range between -6.3 and -9.8 and between 1.81 and 1.58 Ga (n=12), respectively and suggest that they were derived from a composite source area, separated from the mantle during the Paleoproterozoic with little contribution from juvenile younger material. The Ordovician volcaniclastic succession (Volcancito, Bordo Atravesado, Suri and Molles formations) shows T_{DM} between 1.87 and 1.27 Ga and eNd(490) between-3.1 and -12.2 (n=18), consistent with progressive contribution from juvenile material related to the Ocloyic magmatic arc (Collo et al. 2008).

The mixture of early Paleozoic, Neo- and Mesoproterozoic populations in the Cambrian units of Famatina, associated with Paleoproterozoic T_{DM} ages, is typical of lower Paleozoic Gondwana rocks. We suggest that Pampean (~520 Ma), Braziliano (~635 Ma) and Grenville-Sunsás (~1000 and ~1200 Ma) sources were relatively close to the basin during their sedimentation. It seems probable that a Grenville terrane, with an isotopic Gondwanic affinity (a southern extension of the Arequipa-Antofalla massif ?; Lucassen et al. 2000, Casquet et al. 2006), accreted against the Río de La Plata craton at ca. 560-630 Ma. The development of a Brazilian arc upon Mesoproterozoic basement as a product of a west-dipping Neoproterozoic subduction in the central proto-Andean region, allows better explanation for the recorded Meso and Neoproterozoic zircon populations. The closest source for Cambrian populations seems to be the Pampean belt to the east of Famatina, implying rapid uplift and partial exhumation of the Pampean orogen and allowing to interpret earlier deposition within a west prograding peripheral foreland basin. The east-dipping subduction along the western margin of Gondwana, associated to the Ocloyic Orogeny and to the Terra Australis orogenic supercycle, is evidenced by the Ordovician Famatina arc rocks which show a higher contribution of juvenile material.

References

Adams, C.J., Miller, H., Toselli, A.J. and Griffin, W.L., 2008. The Puncoviscana Formation of Northwest Argentina: U-Pb geochronology of detrital circons and Rb-Sr metamorphic ages and their bearing on its stratigraphic age, sediment provenance and tectonic setting. *N. Jb. Geol. Paläont. Abh.,* 247 (3): 341-352.

Casquet, C., Pankhurst, R.J., Fanning, M., Baldo, E., Galindo, C., Rapela, C.W., González-Casado, J.M. and Dahlquist, J.A., 2006. U-Pb SHRIMP zircon dating og Grenville metamorphism in Western Sierras Pampeanas (Argentina): Correlation with the Arequipa-Antofalla craton and constraints on the extent of the Precordillera Terrane. *Gondwana Research*, 9 (4): 524-529.

Collo, G., Stang, A.E., Astini, R.A., Do Campo, M.D., Escayola, M. and Pimentel, M. 2008. Sm-Nd isotopic data from Upper Cambrian - Middle Ordovician Famatinian successions showing a progresive influence of the Ocloyic arc. *VI South American Symposium on Isotope Geology,* 151.

Collo, G., Astini, R.A., Cawood, P., Buchan, C. y Pimentel, M. 2009. U-Pb detrital zircon ages and Sm-Nd isotopic features in low-grade metasedimentary rocks of the Famatina belt: implications for late Neoproterozoic-Early Paleozoic evolution of the proto-Andean margin of Gondwana. Journal of the Geological Society of London, 166, 1-17.

Lucassen, F., Becchio, R., Wilke, G., Franz, G., Thirlwall, M.F., Viramonte, J. and Wemmer, K., 2000. Proterozoic-Paleozoic development of the basement of the Central Andes (18-26°S) – a mobile belt of the South American craton. *Journal of South American Earth Sciences*, 13, 697-715.

Rapela, C.W., Pankhurst, R.J.; Casquet, C.; Fanning, C.M.; Baldo, E.G.; Gonzalez-Casado, J.M.; Galindo, C. and Dahlquist, J., 2007. The Rio de la Plata craton and the assembly of SW Gondwana. *Earth-Science Reviews,* 83 (1-2): 49-82.

Schwartz, J.J. and Gromet, L.P., 2004. Provenance of a late Proterozoic-early Cambrian basin, Sierras de Córdoba, Argentina. *Precambrian Research*, 129: 1-21.

Steenken, A.; Siegesmund, S.; López de Luchi, M.G.; Feri, R. and Wemmer, K. 2006. Neoproterozoic to Early Palaeozoic events in the Sierra de San Luis: implications for the Famatinian geodynamics in the Eastern Sierras Pampeanas (Argentina). *Journal of the Geological Society*, 163: 965-982.

Mechanisms of marine forearc basin evolution along the accretive margin of south central Chile; insights from seismic data and analogue simulations

Contardo X 1, Kukowski N 2, Jensen A 1

1 Doctorado en Ciencias mención Geología. Depto. Cs Geológicas, UCN. Antofagasta, Chile

2 GeoForschungsZentrum Potsdam, Telegrafenberg D-14473 Potsdam, Germany.

3 Current address: Escuela de Ciencias del Mar, PUCV, Valparaíso, Chile. ximena.contardo@ucv.cl

The tectono-sedimentary development of marine forearc basins on the shelf and slope is strongly linked to the morphology and growth history of accretionary prisms and consequently to the evolution of mass transfer process at convergent margins.

The accretionary segment of the Chilean margin extends from Valparaiso (33°S), where the Juan Fernandez Ridge (JFR) collides with the continent, southwards down to the Diego Ramirez Islands at 56°30′S[7]. Since the end of the Tertiary, the South Central Chilean forearc has been accretive, with earlier fluctuations characterized by accretive, non-accretive or erosive modes, which are linked to temporal variations of sediment thickness in the trench. These modes have been associated with changing sediment supply due to climatic fluctuations[1,9,13]. Bangs and Cande (1997) have associated the recent accretive stage to the initiation of Pleistocene glacial erosion in the Main Cordillera.

However, the accretionary wedge off south central Chile also displays differences in size, morphology, and structural styles along the margin, indicating some variations in the mass transfer modes (i.e. ratio of frontal to basal accretion) at different latitudes. As the slope basin deposits constitute records of deformation of the forearc region, the size and distribution of accommodation spaces in slope basins may allow to draw conclusions about present or past material transfer modes. The available accommodation space will influence the volume of sediment derived from the continent which is either trapped in basins or which may reach the trench. On the other hand, the presence or absence of trench fill will affect mechanical properties along the plate interface and therefore the styles of accretionary wedge formation.

A better understanding of parameters which control the history of forearc basins is important for unraveling the long-term tectonic evolution of a convergent margin, as well as to identify the conditions for potential accumulation of hydrocarbons, but also seems important to understand variations in seismicity. From the analysis of new high resolution seismic data across the south central Chile margin (33º30' and 36º50'S), the main characteristics of the architecture and geometry of basins on the middle and upper slope were recognized. The width of basins ranges from 2 to 15 km and the sedimentary infill is about 200 to 1000 m thick.

Asymmetric half-graben basins characterize the middle and upper slope, these basins are mainly controlled by differential movements along bordering faults. The architecture of the sedimentary infill (middle Pleistocene to Holocene) evidences three main distinctive seismic sequences, identified as basal pre-kinematic, intermediate syn-kinematic, and upper post-kinematic units. Although the absolute thickness of each of these sequences varies from basin to basin, the intermediate, syn-kinematic sequence is commonly thicker, associated with high sedimentation rates coeval with slip on bordering faults. Such a sedimentary pattern is linked to tectonic cycles which can be associated with accretionary and non accretionary episodes. Age estimations on boundaries between these units evidence first-order deposition cycles of approximately 100 ky which can be correlated with global climate fluctuations.

The structural controls identified on slope basins reveal at least two mechanisms

for slope basin formation: one of them (more local) is associated with subducting seamounts, in the wake of which considerable subsidence of basins occurs and major accumulation space is created.[4,8,13.]

A second mechanism is linked to differential uplift and subsidence of the upper part of the slope, controlled by large volumes of sediment basally accreted beneath the buttress, which then is undergoing deformation and tilting[12]. On the other hand, the contraction and thickening of the rear part of a wedge represents an efficient mechanism to develop a shelf basin, without collapse related to local extension or subduction erosion, as suggested by Larroque et al. (1995). This process is strongly connected with the available volume of sediments at the trench and the basal properties of the sediments. Climatic fluctuations and currently active canyons represent an important supply of sediments to the system.

The dynamics of the deposition and deformation of the different sequences suggest alternating episodes of extension, relative stability and compression (and/or transpression). Positive flower structures evidence current transpressional activity, associated with tectonic inversion and differential uplift of the accretionary prism.

The characteristic and widely distributed depositional pattern identified in slope basins fill as basal pre-kinematic, intermediate syn-kinematic, and upper post-kinematic units, reveals tectonic cycles which may be linked to accretionary, non-accretionary, or erosive episodes as suggested by Bangs and Cande (1997) for the development of the south Chile margin. However, the nature of the relationship between these tectonic episodes and the sedimentary pattern (pre-, post-, and syn-kinematic sequences), as well as mechanisms controlling the formation of accommodation spaces remains to be elucidated.

To achieve a better understanding of the mechanisms involved in generating the actual geometry and architecture of the accommodation space of marine forearc basins and the evolution of the accretionary margin along the south central Chilean convergent margin, scaled sandbox analogue experiments were performed[3]. We investigate how key-parameters, such as a variable thickness of the incoming sand layer and variable mechanical properties of the basal interface, influence the evolution of the accretionary wedge and consequently the creation or reduction of slope basins and its potential tectono-sedimentary pattern.

We found changes of the mechanical (i.e. frictional) properties of the basal interface a most promising mechanism controlling the evolution of forearc basins. Subvertical thrust faults produced at the interface between high and low basal friction are comparable with the geometry of basin bounding faults observed in seismic lines of the South Central Chilean Margin. The development of episodes of frontal or basal accretion will depend on the length and succession of segments of high and low basal friction. A sand layer above short alternating segments of weak and strong basal friction leads to the evolution of a frontal wedge, which in turn changes to basal accretion above a long segment with a strong basal interface. In this way, we can explain the succession of these tectonic episodes associated with pre-, syn, and post-kinematic units observed in slope basins.

It was also observed that a long segment of low basal friction, followed by a long segment of high basal friction, leads to underthrusting and finally underplating of a long sand layer without deformation. Resulting is deformation in the wedge, through reactivation and propagation of faults towards the backstop. A long, basally accreted layer may correspond to a subduction channel, a feature, which has been also identified from deep seismic images.

It is suggested that differences observed in the degree of uplift and extension of the wedge, as well as in size and deformation of marine forearc basins at different latitudes of South Central Chilean margin, would be directly linked with different stages of basal underplating. Besides, it can be observed that significant changes in the morphology along the accretionary margin and consequently in size and distribution of accommodation spaces, will be strongly influenced by a distinctive sedimentary source controlling changes in volume and physical properties of the trench sediments (i.e., marine currents, active canyons and climate events among others).

Acknowledgements: This study is in the framework of a Ph.D. thesis funded by the Dirección de Investigación of the Universidad Católica del Norte, in Antofagasta-Chile. We thank Dr. José Cembrano whom participated as co-tutor of this thesis project. We also thank the FONDEF Project D00I1104; a Chilean project which financed the VG02 cruise, whose co-chief scientists were Juan Diaz-Naveas and Holger Lykke-Andersen. We want to express our gratitude to the German Academic Exchange Service (DAAD) for funding the X.C. visit to perform the analogue experiments in the Geodynamics Laboratory of the Deutsche GeoForschungsZentrum in Potsdam, Germany, in summer 2006. A short visit of X.C. to Potsdam in 2005 was partially granted by Fundación Andes.

References

Bangs, N., Cande, S., 1997. Episodic development of a convergent margin inferred from structures and processes along the southern Chile margin. Tectonics 16, 489–503.

Contardo, X., Cembrano, J., Jensen, A., Díaz-Naveas. J. 2008. Tectono-sedimentary evolution of marine slope basins in the Chilean forearc (33°30′–36°50′S): Insights into their link with the subduction process Tectonophysics, doi:10.1016/j.tecto.2007.12.014.

Contardo, X., Kukowski, N., Cembrano, J. Controls on the formation of slope basins along the south central Chilean convergent margin: Insights from scaled sandbox simulations (submitted to Tectonophysics).

Dominguez, S., Lallemand, S., Malavieille, J., von Huene, R., 1998. Upper plate deformation associated with seamount subduction. Tectonophysics, 293, 207-224.

González, E., 1989. Hydrocarbon resources in the coastal zone of Chile, in geology of the Andes and its relation to hydrocarbon and mineral resources. Earth Science Series, vol. 11. Circum-Pacific Council for Energy and Mineral Resources, Houston, Texas, pp. 383–404.

Gutscher, M., Kukowski, N., Malavieille, J., Lallemand, S. 1996. Cyclical behaviour of thrust wedges; insights from high basal friction sandbox experiments. Geology 24:135-138.

Larroque, C., Calassou, S., Malavieille, J., Chanier, F., 1995. Experimental modelling of forearc basin development during accretionary wedge growth. Basin Research 7, 255-268.

Laursen, J., Normark, W., 2002. Late Quaternary evolution of the San Antonio Submarine Canyon in the central Chile forearc (33°S). Mar. Geol. 188, 365-390.

Lohrmann, I., Kukowski, N., Oncken, O., 2001. Erosive and accretive mass transfer modes and related deformation at the Chilean forearc — results of 2D scaled sandbox experiments. I. Scientific Report for Research Period 1999–2001. Collaborative Research Center SFB 267. Berlin, Potsdam, pp. 395–421.

Lohrmann, J., Kukowski, N., Krawczyk, C., Oncken, O., Sick, C., Sobiesiak, M., Rietbrock, A. 2006. Subduction channel evolution in brittle forearc wedges – a combined study with scaled sandbox experiments, seismological and reflection seismic data and geological field evidence. In: Oncken O, Chong G, Franz G, Giese P, Götze H-J, Ramos VA, Strecker MR, Wigger P (eds) The Andes – active subduction orogeny. Frontiers in Earth Science Series, Vol 1. Springer-Verlag, Berlin Heidelberg New York, 237–262.

Kukowski, N., von Huene, R., Malavieille, J., Lallemand, S., 1994. Sediment accretion against a buttress beneath the Peruvian continental margin at 12°S as simulated with sandbox modelling. Geol. Rundsh 83, 822–831.

Kukowski, N., Lallemand, S., Malavieille, J., Gustcher, M.-A., Reston, T., 2002. Mechanical decoupling and basal duplex formation observed in sandbox experiments with application to the western Mediterranean Ridge accretionary complex. Marine Geology 186, 29-42.

Kukowski, N., Oncken, O., 2006. Subduction erosion — the "normal" mode of fore arc material transfer along the Chileanmargin?. Chapter 10 The Andes, Active Subduction Orogeny. Frontiers in Earth Sciences. Springer Verlag, Berlin, pp. 217–236.

Llenos, A., McGuire, J., 2007. Influence of fore-arc structure on the extent of great subduction zone earthquakes, *J. Geophys. Res.*, *112*, B09301, doi:10.1029/2007JB004944.

Song, T., Simons, M. 2003. Large trench-parallel gravity variations predict seismogenic behaviour in subduction zones, Science, 301, 630– 633.Wells et al., 2003;

Wells, R., Blakely, R., Sugiyama, Y., Scholl,D., Dinterman, P. 2003. Basin-centered asperities in great subduction zone earthquakes: A link between slip, subsidence, and subduction erosion?, J. Geophys. Res., 108(B10), 2507, doi:10.1029/2002JB002072.

Lake landscape on lateritic iron crust over high plateaus in the eastern Amazon

Costa ML 1, Trindade A 1, Behling H 2, Hermanowski B 2

1 Institute of Geosciences, Federal University of Pará, Belém (Pará), Brazil, mlc@ufpa.br
2 Department of Palynology and Climate Dynamics, University of Goettingen, Germany

The rain forest of the Amazon region involves a huge fluvial and lacustrine flood plain drainage systems and mountains and high plateaus as well. The plateau landscape is developed on thick lateritic iron crust 400 m to 900 m high, covered today by edaphic savanna, while the rain forest is found on the plateau slopes. On the top of the iron crust bearing plateaus several small lakes and sedimentary lake sediments have been formed. Carajás, a world important ore mineral province, presents as very representative example of this landscape and is therefore our research area. The lakes and its deposits have been established in sub circular to elliptical depressions over Paleocene thick lateritic iron crusts, which outcrop everywhere. Several lake sediments have been subject for coring. The Cachoeira lake is selected for this paper.

The sediment core from Cachoeira is 538 cm long and shows two important layers: a 423 cm thick yellowish to brownish slight cohesive clayey like package (YBC) with intercalations of dark brown to gray material carrying very fine organic matter, that diminishes in frequency and thickness in the depth; and at top a 115 cm thick layer characterized by the domain of organic matter debris (OMD), whereby the first surficial 12 cm consists practically of organic matter debris only, and the next 103 cm shows a gradual increasing of mineral mud until to the underlying yellow to brown clayey like layer. The YBC presents brown sandy concretions made of carbonate, which increases in frequency and diameter with the depth. The debris, grain or crystal size decreases with the depth (400 to 40 µm or less). The OMD (0 to 115 cm depth) shows many sponges spicules of silica-rich cauixi and other OM forms, very common in the lakes of the Amazon, which ongoing disappear into the thick YBC. In this layer quartz is the unique crystalline mineral phase that probably come from the surrounding iron crust, where it is a minor phase in the domain of hematite and goethite, and some gibbsite. The 423 cm thick YBC layer comprises three beds after color changing from yellow-brown to dark brown and mineral composition from the base to the top, which correspond to the intercalations mentioned earlier: an yellow to brown bed at 420 to 538 cm in depth made of quartz + goethite + *siderite*; a domain of dark brown bed at 277 to 420 cm constituted of quartz + goethite, sometimes siderite, and some very fine OM; an yellow to brown bed at 195 to 277 cm in depth by quartz + *kaolinite* + goethite + siderite; and at the top a yellow bed at 103 to 195 cm in depth which is formed by quartz+*siderite*+goethite. It indicates a clear layer alternation, characterized by the presence of siderite or kaolinite/goethite, besides OM which occurs associated to kaolinite. Siderite builds the sandy-like concretions and turns the sediments cohesive and much browner in color.

Siderite also imprints the sandy aspect of the sediments and develops corroded rhombohedra crystals covered by kaolinite. The two siderite beds have been already recognized by Soubiés et al (1991) in other lakes from Serra Sul and Costa et al (2005) from Serra Norte in Carajás region.

The 423 cm thick YBC sediments as expected from the mineralogy are rich on Fe_2O_3 and/or FeO (up to 69 wt. %), as much as in the iron crusts, besides SiO_2 (8.8 – 32.7 wt. %) and some Al_2O_3 (5.5 – 16.9 wt. %). The higher values of Fe_2O_3 and/or FeO have been found at 277 to 420 cm depth, where goethite domains and some fine OM occur. The contents of the alkaline and earth alkaline elements (Mg, Ca, Na and K) are < 0.1 wt. % and TiO_2 around 0.6 to 1.4 wt. %. This chemical composition can be closely correlated to a lateritic iron crust, very rich on Fe and poor on alkali elements, exactly it occurs in the Cachoeira lake area. The contents of trace elements are very low what indicated again an iron crust weathering derived from banded iron formation. The relative high contents of SiO_2 in the siderite bed may be an indication of the richness of living silica-bearing organisms during the two phases of siderite formation. The relative high contents of P_2O_5 (0.2-0.9 wt. %) in these sediments, very low in the iron crust, may be explained by living aquatic animals and birds already in the earlier stages of sediment deposition.

The results show that the lake sediments from Cachoeira had in fact the surrounding lateritic iron crusts as source area, as could be expected and observed by Costa et al (2005) in lakes of Serra Norte from Carajás. Probably they were at late Pleistocene time (radiocarbon dating show that the late 200 cm have been formed in last 21,723 ± 190 yr BP) exposed to mild climate. Kaolinite, a rare mineral in the iron crust, has been observed only in the bed at 195 to 277 cm in depth. Kaolinite can be found as a product of the tropical weathering of iron crust, well known in other places at Carajás region (Horbe and Costa, 2005). Kaolinite-free beds may represent a mild climate and the kaolinite-bearing a humid climate. The weathered or unweathered iron crusts have been eroded and transported to the lake by water leaching (run off) and small drainage. Probably no rain forest established around the margin of the Cachoeira lake and organic matter observed may represent time of low and high level of lake water. Possibly two events of low level (less than 100 cm) of lake water may be represented by much more carbon-rich OM, indicated by siderite, which has been formed by diagenesis. The formation of wide spreading of siderite indicated a high consumption of carbon-rich OM by promoting its oxidation through the sediment pore water. The last 115cm indicate a gradual transition from quartz+goethite+siderite+OM into a layer of OM alone, directly related to lake water bed, 100 cm depth, plentiful of life: macrophytes, grass, small shrub, some reptiles, fish, birds and sponges.

References

Costa M L, Carmo M S, Behling H (2005) Mineralogia e geoquímica de sedimentos lacustres com substrato laterítico na Amazônia brasileira. Revista Brasileira de

Geociências São Paulo 35 (2): 165-176.
Horbe A C, Costa M L (2005) Lateritic crusts and related soils in eastern Brazilian Amazonia. Geoderma (Amsterdam) 126: 225-239.
Soubiés F, Suguio K, Martin L, Leprun J C, Servant M, Turcq B, Fournier M, Delaune M, Siffeddine A (1991) The Quaternary lacustrine deposits of the Serra dos Carajás (State of Pará, Brazil) – ages and other preliminary results. IG-USP Spec. Publ. 8: 223-243

U-Pb La-ICP-MS geochronology of detrital zircons from Lower Palaeozoic rocks of the Eastern Cordillera, NW Argentina: Tectonic significance for the evolution of Western Gondwana

Cunzolo S 1, Pimentel M 2

1 Facultad de Ciencias Naturales e IML, UNT, CONICET, INSUGEO, Miguel Lillo 205, Tucumán 4000, Argentina, sonia77ar@yahoo.com
2 Laboratório de Geocronologia, Instituto de Geociências, Universidade de Brasilia, Brasilia-DF 70910-900, Brazil, marcio@unb.br

The provenance of Lower Paleozoic sandstones exposed in the central sector of the Humahuaca´s Creek valley , northwestern Argentina, was investigate in the present study. Detrital zircons grains, were analysed by the U-Pb LA-ICPMS method. The studied samples are sandstones from the lower portion of the Cambrian-Ordovician Casa Colorada Formation (Lopez and Nullo 1969) in the neighbourhoods of Casa Colorada and Huacalera. The Cambrian-Ordovician sequence has been interpreted as in a N-S intracratonic basin, developed along the western margin of Gondwana between the Eastern Puna-Famatina Terrane in the west and the Pampean Arc to the east. The main objective of this study, was to contribute to the paleogeographic reconstructions of the western margin of Gondwana Detrital zircon age patterns display mainly Neoproterozoic ages (0.54-0.63-0.79 Ga), with a subordinate Mesoproterozoic (1.04-1.26-1.44 Ga) population. A small Paleoproterozoic population (1.89-2.12 Ga) is also observed. Neoarchean zircons, were identified in both sections, with peaks at approximately 2.53 and 2.68 Ga. These results are similar to those presented by Di Cunzolo and Pimentel (2008), differing from them only in the absence of Paleoarchean ages. We suggest a Gondwana origin for the original sediments, which deriver from the erosion of the southwest margin of the Brasilian Platform. Neoproterozoic zircon grains were most probably derived from the Brasiloiano Belts and the Goiás Magmatic Arc, in central Brazil, whereas the Mesoproterozoic and Neoarchean ages derived from the Amazon craton.

References

Di Cunzolo, S. C. and Pimentel, M. M. (2008) LA-ICPMS U-Pb Provenance data for detrital zircons of Cambro-Ordovician units of the Quebrada de Humahuaca, Jujuy province, Argentina: Tectonic significance. *VI South American on Isotope Geology*. San Carlos de Bariloche, Argentina. CD ROM.
Lopez, C. R. and Nullo, F. E (1969) Geología de la margen izquierda de la Quebrada de Humahuaca, de Huacalera a Maimará. Departamento Tilcara - Provincia de Jujuy, República Argentina. *Revista de la Asociación Geológica Argentina* 24 (3): 173-182.

New evidence of ammonites and its sedimentary context within Upper part of Chokolate Formation (Yura, Arequipa)

De la Cruz AA, Acosta-Pereira H, Aldana M

Instituto Geológico Minero y Metalúrgico INGEMMET, Dirección de Geología Regional. Av. Canadá N° 1470, San Borja, Lima, Perú, aavan@ingemmet.gob.pe

In District of Yura, Province and Department of Arequipa (southern Peru), there are several studies in petrology and stratigraphy (Jenks, 1958; Benavides, 1962; Vargas, 1970; Vicente, 1981; León, 1981; Vicente qt al., 1982). In this study, we show an update on knowledge of sedimentological and paleontological elements in Chocolate Formation, in cerro Yanacoto; reporting for this area fluvial and marine sedimentary sequences, both containing fauna of ammonites in marine facies. This study relates paleontological features on the sedimentological context in which the ammonites were found.

At cerro Yanacoto, up to 170 m. in the stratigraphic column (at the top of the Sequence 1) at Chocolate Formation, there are layers containing carbonated silty sediments, that contain two fossiliferous levels, separated each other by 50 cm. in thickness by fine grained sandstone, collected at total about ten internal molds of ammonites found in normal position and regular state conserved. These are ammonites, which paleontological features consists of small size, umbilical diameter about 2 to 5 cm., first whorl height range between 1.5 to 2 cm., evolute to slightly involute, some samples, can be observed at least 4 whorls, venter is slightly rounded and very narrow, and the ornamentation consists of simple and straight ribs on the flanks; and on its ventro-lateral shoulders, bending are observed toward growth direction of the shell. These characteristics correspond to Arietitidos. Regarding *Uptonia* sp., they are compressed, with coarse ribs and coarse to slightly regular folds relatively next to ventral zone, they are not tuberculated.

These ammonites were found in a siltstone-shales intercalation, some of them with thin sandstone layers and calcareous components within a ~2 meter strata, which there are two fine grained levels. In the first level, there are the ammonites *Megarietites* sp., *Eparietites* sp. and *Uptonia* sp., followed by a chaotic sedimentation

represented by convoluted laminations, accompanied by synsedimentary normal microfaults cutting unconsolidated layers; above these levels, the second level is located, containing *Megarietites meridionalis* (REYNES), *Eparietites* cf. *undaries* (QUENSTEDT) and *Arnioceras* sp.

The presence of ammonites Arietítidos, is characteristic of Sinemurian times, Arietitidos ammonites reported in this study are present in Lower Sinemurian beds in northern Siberia and in the Mediterranean Sinclinal Belt in Russia (Krymholts et al., 1988), these environments are relatively deep, and also, there are reported I relatively shallow marine water. Moreover, sedimentary evidences suggest a deltaic sedimentary environment, in a slope with strong deformed strata. According to those evidences, is very possible that these ammonites have undergone short post-mortem transport.

In conclusion, ammonites reported at the top part of the Sequence 1 of Chocolate Formation, correspond to *Megarietites meridionalis* REYNES, *Eparietites* cf. *undaries* (QUENSTEDT), *Megarietites* sp., *Eparietites* sp. and *Uptonia* sp.; these are Sinemurian and Lower Pliensbachian ammonites, and lived in relatively deep marine water. These ammonites were found next to post-mortem transport evidences that correspond to a slope facies.

Stratigraphic column in cerro Yanacoto shows a sequence of sedimentary rocks, involving conglomerates, sandstone and siltstone from continental environments, with occasional deposits of siltstone-shales, which correspond to marine sea level rise in thin thicknesses.

References

Acosta H, Alván A, Torres P & Cornejo T (2008) La Formación Chocolate en su localidad tipo: Cantera Chocolate y cerro Yanacoto (Arequipa). XIV Congreso Peruano de Geología: 6 p.

Benavides V. (1962) Estratigrafía Pre-terciaria de la región de Arequipa. II Congreso Nacional de Geología, Tomo 38: 5-63 p.

Jenks, W (1948) Geología de la Hoja de Arequipa al 200,000. Boletín del Instituto Geológico del Perú, Bol. 9.

Krymholts G, Mesezhnikov M & Westermann G (1988) The Jurassic Ammonite Zones of the Soviet Union. Transactions, Vol. 10, Special Paper N° 223: 124 p.

León I (1981) Antecedentes sedimentológicos del Jurásico-Cretácico inferior en la zona de Yura. Tesis de Bachiller, Universidad Nacional de San Agustín: 100 p.

Vargas L (1970) Geología del Cuadrángulo de Arequipa. Boletín del Servicio de Geología y Minería, N° 24: 64 p.

Vicente J-C (1981) Elementos de la Estratigrafía Mesozoica Sur-peruana. Comité Sudamericano del Jurásico y Cretácico: Cuencas sedimentarias del Jurásico y Cretácico de América del Sur. Vol. 1: 319- 351 p.

Vicente J-C, Beaudoin B, Chavez A & León I (1982) La cuenca de Arequipa (Sur Perú) durante el Jurásico-Cretácico inferior. Quinto Congreso Latinoamericano

de Geología, Argentina, Actas, I: 121- 153 p.

Vicente J-C (2005) Dynamic paleogeography of the Jurassic Andean Basin: pattern of transgression and localisation of main straits through the magmatic arc. Revista de la Asociación Geológica Argentina, Nº 60 (1): 221-250 p.

Westermann G, Riccardi A, Palacios O & Rangel C (1980) Jurásico medio en el Perú. Bol. Nº 9, Serie D, Estudios Especiales: 60 p.

Sedimentary facies and ammonites relations between Arequipa and Tacna during Lower to Middle Jurassic

De la Cruz AA , Acosta Pereira H

Instituto Geológico Minero y Metalúrgico INGEMMET, Dirección de Geología Regional. Av. Canadá N° 1470, San Borja, Lima, Per,u. aalvan@ingemmet.gob.pe

Arequipa basin has been studied by different authors, such as Jenks (1848), Wells (1953), Benavides (1962), Vargas (1970), Leon (1981) and Vicente (1981). These authors refer to the layers of the Chocolate Formation (Lower Jurassic) in Arequipa, as a succession of andesitic and sedimentary rocks, containing Sinemurian ammonites. There are geological investigations in localities of Tacna made by Wilson & Garcia (1962), Jaen & Ortiz (1963), Salinas (1987), among others; whose produce the first geological maps of the zone.

Currently, data showed in this report (stratigraphic columns, ammonites paleontology) (Fi. 2), corresponds to a set of information not yet publicated, obtained from INGEMMET field jobs. Data sets were taken from outcrops along coastal strip of southern Peru, in localities of Yura (Department of Arequipa) and ceros Palquilla and Pelado (Department of Tacna) (Fig. 1), within the Arequipa Mesozoic basin, southern Peru. Lower and Middle Jurassic sediments have been analizad in Arequipa (Yura) and Tacna (cerros Palquilla and Pelado) in terms of stratigraphy, sedimentology and paleontology. A taphonomic study of ammonites and its paleoenvironmental and chronological implicances and has been related one to another.

In Cerro Yanacoto, Yura, Arequipa, there is a stratigraphic section, containing to Chocolate Formation as a succession of sedimentary rocks (Acosta et al., 2008), which is correlated with Junerata and Pelado formations (Fig. 2). This succession involves conglomerates, sandstones, and calcareous siltstones, from marine incursion of few thicknesses; in its respective sedimentary facies variations.

Here, the Chocolate Formation contains ammonite fauna, and they are positioned in calcareous siltstone interstratified with very fine grained sandstone; showing us the presence of relatively shallow marine waters. Sedimentation in this fosiliferous levels, presents evidences of submarine turbulence in a prodelta sub-environment, contained in talud facies; being these fossils possibly re-transported post-mortem (Alván et al., 2008). These are the ammonites *Uptonia* sp., *Megarietites* sp. and *Eparieti-*

tes sp.; above these levels, there are *Megarietites meridionalis* (REYNES), *Eparietites* cf. *undaries* (QUENSTEDT) and *Arnioceras* sp., fossils arietítidos that indicate us Upper Sinemurian strata.

In those levels, the presence of ammonites from marine water not so deep, belongs to a deltaic system, in its distal part; referring to a sub-environment of prodelta.

In the localities of Cerro Palquilla and Cerro Pelado, there are sedimentary rocks, that, in the same way, they are disturbed by one or more than one fault or diagenetic processes, produced by extensive tectonics. These sedimentary processes are related to relatively deep marine facies.

In Cerro Palquilla, sedimentary facies in Pelado Formation (Lower Jurassic to Under- Toarcian) and San Francisco Formation (Upper Toarcian to Upper Bathonian), consist of detritus and carbonated facies of turbidites, carbonated platforms and fluvial deposits; from different sedimentary environments within a delta in relatively deep marine water (prodeltas, slope base lobes and deltaic platform). Besides this, there is evidence of carbonatic sedimentation with turbidity currents, stirring all the ammonites in site.

Here, in Pelado Formation, this paper reports 5 fosiliferous levels, that contain the ammonites *Megarietites meridionalis* REYNES, *Megarietites* sp., *Uptonia* cf. *U. ignota* (SIMPSON), *Uptonia* cf. *U. obsoleta* (SIMPSON) and *Uptonia* sp. y *Arieticeras* sp. This clustering indicate us Sinemurian to Toarcian times. Most of these ammonites are positioned in turbidity zones. The "verticality" of the ammonites is lost at depths greater than 10 m. However, this sedimentation is fast and violent, and makes the ammonites be conserved and retained in "vertical" position, as evidenced by submarine turbidity processes.

Similar sedimentary processes, are present in stratigraphic column in cerro Pelado, in Pelado and San Francisco formations, there is evidence of turbidity flows, although the presence of ammonites in carbonated nodules are abundant. Here we have the presence of *Arieticeras* sp., *Megarietites* sp., *Belemnites* sp., *Belemnites paxillosus* LAMARCK. Association of fossils that indicate Sinemurian and Pliensbachian times.

It's considered as a baseline to carbonated deposits, formed since Sinemurian to Toarcian (in Chocolate-Junerata-Pelado and Socosani-San Francisco correlations) (Fig. 2), showing themselves progressive discordances. Thickness of these deposits varies according to their respective paleorelief. The similarity of these deposits between Arequipa and Tacna is extensive. It is considered as correct the comments made to the relationship between Chocolate Formation and Junerata-Pelado formations; as well as the relationship between Socosani Formation and San Francisco Formation, both in lithology and chronology.

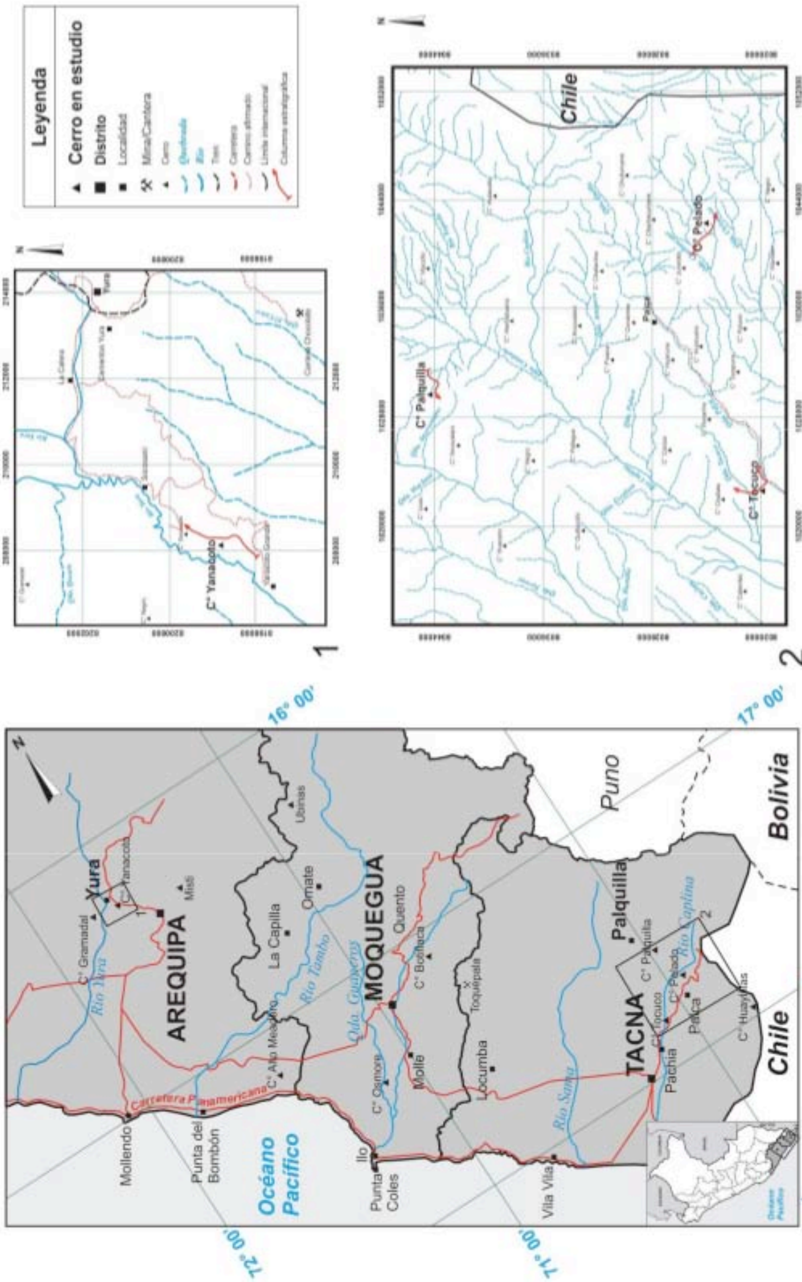


Fig. 1.- Location map and accesibility to localities in study; 1: cerro Yanacoto in Yura, and (2): cerro Palquilla in Tacna. Red arrows indicate us direction of stratigraphic sections.

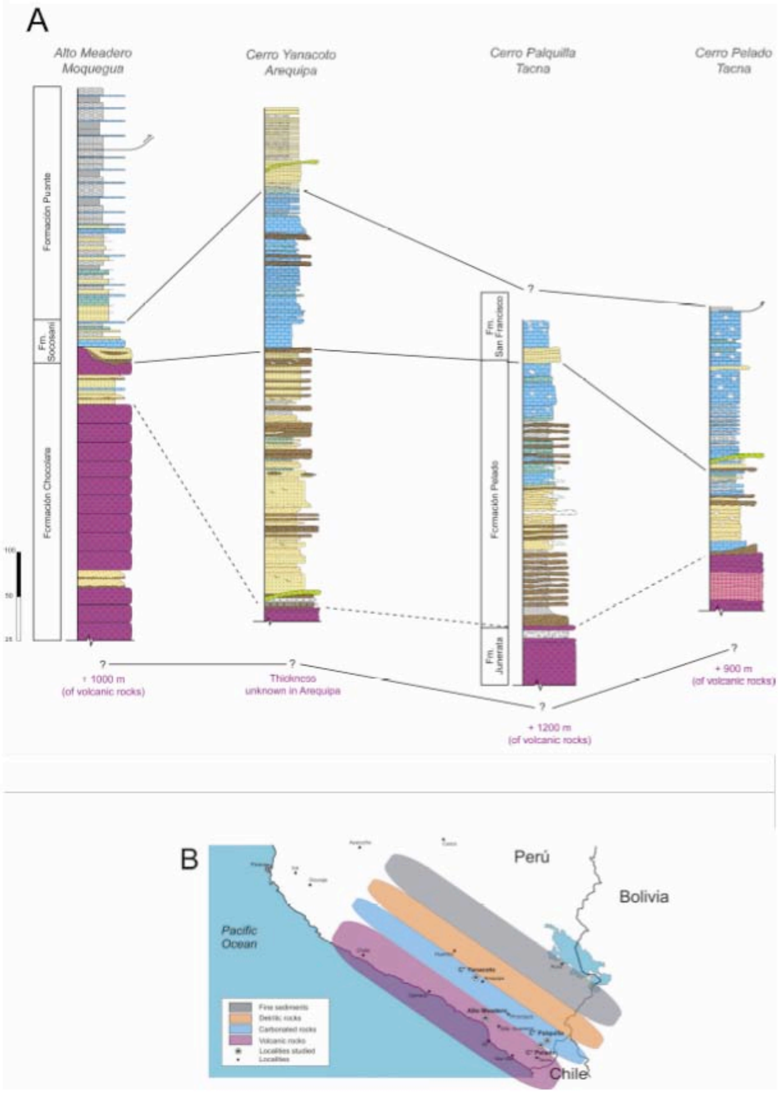


Fig. 2.- A: Representative stratigraphic columns of the Arequipa basin. B: Schematic graphic of the facies in Arequipa basin, southern Peru.

It is interpreted, for southern Peru that, in Sinemurian to Toarcian times, there has started a major marine transgression, where the deposition of carbonate rocks stretches with different thicknesses, described under different names depending on the area, stretching from Arequipa to northern Chile.

Referring to taphofacies, ammonites are deposited in mud layers, in slope environments and slope base, and, in some southern sectors, with fragments of peleci-

pods. Ammonites are Arietitidos, typical relatively deep marine water fossils; their ornamentation consist of simple ribs, straight at sides and leaning toward to opening near the venter zone, without tubercules. In its ventro-lateral shoulders, inflections are observed, tending to the direction of shell growth; being these ammonites typical from calm water and seep seas in Sinemurian times. In the localities of Tacna, there are pavements made of mud, ammonites and bivalves, in evident sedimentary disturbation, from turbiditic environments. Taphonomic main features are verticality of buried ammonites in limestones levels, which are interspersed with conglomerated beds, interpreted as submarine channels. These characteristics of synsedimentary deformation, extensive tectonic environments, are along all southern Peru strip, showing post-volcanic extensive activity.

References

Acosta H, Alván A, Torres P, Cornejo, T (2008) La Formación Chocolate en su localidad tipo: Cantera Chocolate y el cerro Yanacoto (Arequipa). XIV Congreso Peruano de Geología: 6 p.

Alván A, Acosta H, Aldana M (2008) Nuevas evidencias de ammonites en el contexto sedimentario de la Formación Chocolate (Yura, Arequipa). XIV Congreso Peruano de Geología: 6 p.

Benavides V (1962) Estratigrafía Pre-terciaria de la región de Arequipa. II Congreso Nacional de Geología, Tomo 38: 5-63. Jenks W (1945) La geología de la región Arequipa y sus alrededores. Informaciones y Memorias de la Sociedad de Ingenieros del Perú, Vol. 46: Nº 9.

León I (1981) Antecedentes sedimentológicos del Jurásico-Cretácico inferior en la zona de Yura. Tesis de Bachiller, Universidad Nacional de San Agustín: 100 p.

Salinas E (1985) Evolución paleogeográfica del sur del Perú a la luz de los métodos de análisis sedimentológicos de las series del departamento de Tacna. Universidad Nacional San Agustín de Arequipa, Tesis para optar el titulo de Ingeniero Geólogo: 205 p.

Vargas L (1970) Geología del cuadrángulo de Arequipa (Hoja 33-s). Servicio de Geología y Minería N° 24: 64 p.

Vicente J C (1981) Elementos de la Estratigrafía Mesozoica Sur-peruana. Comité Sudamericano del Jurásico y Cretácico: Cuencas sedimentarias del Jurásico y Cretácico de América del Sur. Vol. 1: 319- 351.

Thermobarometry and geochronology of metapelites and granitoids of the eastern Sierra de Velasco, Sierras Pampeanas, Argentina: P-T paths and exhumation rates during the Famatinian Cycle

De los Hoyos C 1, Willner AP 2, Larrovere M 1, Rossi J 1, Toselli A 1

1 INSUGEO-CONICET. Miguel Lillo 205. 4000-Tucumán, Argentina, camilodlh@yahoo.com.ar
2 Inst. f. Geologie, Mineralogie, und Geophysik, Ruhr-Universität, 44780 Bochum, Germany

The Sierra de Velasco belongs to the Eastern Sierras Pampeanas of NW-Argentina and is formed almost exclusively by Famatinian shear-deformed and undeformed I- and S-type granitoids corresponding to two age groups: Lower/Middle Ordovician and Lower Carboniferous granitoids (e.g. Báez et al., 2005). The metasedimentary host-rock, the La Cébila Formation (LCF), crops out as small N-S belts along the eastern flank of the sierra. Most Ordovician granitoids are affected by NNW-SSE Devonian shear zones, whereas the Carboniferous ones are undeformed.

The eastern flank of the sierra is composed of probably Ordovician S-type granitoids that intruded into the LCF. This block in turn was intruded by Carboniferous granites. Field observations combined with petrographical and geochemical studies suggest that the LCF was first intruded by moderately to strongly peraluminous tonalites and granodiorites. Irregular to diffuse contacts and coeval migmatization of the host-rock with the assemblage Grt+Bi+Wm+Sil+Pl+Qtz indicate a relatively deep emplacement level for these bodies, whereas shear deformation affecting them suggests a probable Ordovician age. These granitoids and the LCF were in turn intruded by Crd-bearing granites at shallower levels, because of sharp contacts with the development of Crd-Sil-Kfs-Bi-bearing hornfelses (Rossi et al., 2005). The relatively deeply-emplaced granitoids and the shallower Crd-bearing granites are referred to as DEG and CBG respectively. These units were finally intruded by the Huaco and Sanagasta S-type plutons in Early Carboniferous times (Grosse et al., 2008) at emplacement levels probably shallower than those for the CBG. Samples collected for thermobarometric and geochronological studies are as follows: 7992, representing a Grt-Bi-Ms-Pl-Sil migmatite ~2 Km away from the contact with the DEG; 7993, a Grt-Bi-Ms-Pl-Sil-bearing migmatite immediately at the contact; 7901, a Crd-Sil-Bi-Wm-Pl-bearing hornfels septa within the CBG; 7833 and 7903 representing the DEG and CBG respectively.

Monazite single-grain fractions from 7833 and 7903 were analyzed by the ID-TIMS method for U-Pb dating. Early/Middle Ordovician ages were obtained for both samples: 476±2 Ma (MSWD=0.5) for 7833 and 472±16 Ma (MSWD=1.5) for 7903. In addition, Pb, Th and U contents in monazite cores and rims within two polished sections of 7992 (leucosome and mesosome) were analized *in situ* using an electron microprobe. We found no important difference in monazite compositions from leucosomes and mesosomes, and a mean age of 477.2±4.7 (2σ)

Ma (MSWD=?) was acquired from 21 grains, in good agreement with ID-TIMS ages for the DEG, suggesting that the migmatization of the host-rock was coeval with the intrusion.

For thermobarometry major elements for minerals within 7992, 7993 and 7901 were analyzed *in situ* using an electron microprobe. A whole-rock powder representing 7901 was analyzed for major elements to be used to calculate a P-T pseudosection.

The mineral assemblage within 7992 and 7993 permitted to use conventional and multiphase-equilibria thermobarometric methods. Spessartite profiles for garnets within 7992 are nearly flat in cores and inner rims with an increase in this component towards outer rims, indicating homogenization by high-temperature diffusion. Garnet core and rim compositions for 7992 combined with Wm and Bi inclusions yielded average P-T values of 610-577°C and 4.8-4.4 Kbar for cores and rims respectively. Some spessartite profiles for relatively large garnets in 7993 are "bell-shaped", suggesting preservation of the prograde history. Garnet rim compositions and small "spessartite-flat" garnets with biotite and white mica from the matrix yielded average values of 728°C and 6.4 Kbar. Multiphase equilibria calculations (TWQ 2.32 software; Berman, 1991 with the corresponding database to different versions) yielded average temperatures of 598-565°C for garnet cores and rims in 7992, while 717°C was calculated for garnet rims in 7993. Pressures for garnet cores in 7992 and rims in 7993 were not determined because of the lack of plagioclase inclusions in 7992 and the low grossular content in 7993. An average pressure of 4.3 Kbar was obtained for garnet rims in 7992.

The P-T pseudosection for 7901 was calculated using the Perplex software (Connolly & Petrini, 2002) to reconstruct stability fields of theoretical assemblages and compare them to observed mineral assemblages. For sample 7901, a small stability field was calculated for the assemblage Bt+Wm+Crd+Pl+Sil+Qtz, in good agreement with the observed assemblage. The stability field is within the range of T=600-645°C and P=2.2-2.6 Kbar, and gives a good estimate of the emplacement conditions for the CBG.

Combining the results from different methods, the LCF underwent a clockwise P-T path during Ordovician times. Loading during prograde garnet growth buried the block to a crustal level of ~24 Km. Subsequently, nearly isothermal decompression during exhumation was accompanied by extensive granite intrusion at ~17 Km depth, followed by a final stage of nearly isobaric cooling. Probably during Middle Ordovician, the block was exhumed to depths of ~9 Km and intruded by the CBG. Despite the low resolution in ages for metamorphism and intrusion, exhumation rates can roughly be estimated. If prograde garnet within 7993 grew at the beginning of the Famatinian cycle (~490 Ma) and granitoids of the Sierra de Velasco intruded within a period of around 480-460 Ma, about 7 Km crust were exhumed in ~10 Ma, giving a relatively fast initial exhumation rate of 0.7 mm/yr during Early Ordovician. During Early to Middle Ordovician, about 8 Km crust would have been exhumed in around 20 Ma before the intrusion of the CBG, giving a slower rate of 0.4 mm/yr

for this period. Between the Middle Ordovician and Early Carboniferous, the entire sequence was exhumed and intruded by the Huaco Pluton at ~7 Km depth, giving a by an order of magnitude slower exhumation rate of 0.02 mm/yr. Thus, exhumation was first fast and then slowed down up to a steady-state stage between the Middle Ordovician and Early Carboniferous. This stage was accompanied by shear deformation in the Devonian and followed by S-type magmatism. If extensive shear deformation was related to a collisional event it is unlikely to be orthogonal, but rather oblique or strike-slip, because exhumation is virtually absent.. All exhumation rates are consistent with erosion as prime exhumation factor.

References

Báez, M. A., Bellos, L. I., Grosse, P., Sardi, F. G., 2005. In: Dahlquist, J., Rapela, C., Baldo, E. (Eds.): Geología de la provincia de La Rioja -Precámbrico-Paleozoico Inferior. Asociación Geológica Argentina, Serie D, Publicación especial Nº 8: 123-130.

Rossi, J.N., Toselli, A.J., Prieri, A., Cravero, O. and de los Hoyos, C., 2005. XVI Congreso Geológico Argentino, La Plata, Argentina, pp. 635-638.

Grosse, P., Söllner, F., Báez, M. A., Toselli, A. J., Rossi, J. N., De la Rosa, J. D., 2008. Internacional Journal of Earth Sciences. DOI 10.1007/s00531-007-0297-5.

Berman, R. G., 1991. Canadian Mineralogist 29, 833-855.

Connolly, J.A.D., Petrini,K., 2002. Journal of Metamorphic Geology 20, 697–708.

Geochemical and thermochronological signals in Tertiary to Recent sediments from the Western Andes (15-19°S): proxies for sediment provenance and Andean uplift.

Decou A, Mamani M , Eynatten H , Wörner G

GZG Universität Göttingen, Goldschmidtstr. 3, 37077 Göttingen, Germany, adecou@gwdg.de

During the Cenozoic the landscape at the western margin of South America changed dramatically due to the tectonic evolution of the Andes (Isacks 1988, J Geophysical Res 93) and significant variations in climate (Gregory-Wodzicki 2000, GSA Bulletin 112). At present day the climate in the western Central Andes (N-Chile, S-Peru) is arid (rainfall average is less than 100-200 mm/y) Climate has changed significantly through time, for example, sediments on the Altiplano and the eastern Central Andes indicate a period of increased precipitation at around 7-8 Ma (Gaupp et al. 1999, PPP 151; Uba et al. 2007, Geology 35). The uplift of the Andes started some 30-25 My ago (Isacks, 1988,). Siliciclastic sedimentation along the western flank of the Central Andes started at 55 Ma and lasted until recent time (Moquegua Group, Roperch et al. 2006, Tectonics 25). This implies that a river system with sediment de-

position was already developed before the Andean uplift which occurred during deposition of the Moquegua Group.

The Moquegua group is composed of four units: Moquegua A (55-45Ma), Moquegua B (45-30Ma), Moquegua C (30-15?Ma) and Moquegua D (15?-0Ma) (Roperch et al. 2006). The sedimentary basin of Moquegua has a complex internal structure and is composed of different subbasins. We focus in this study respectively, from north to south, on the Cuno Cuno section (cut by the Rio Ocoña), the Majes section (cut by the Rio Majes) and the Moquegua section (cut by the Rio Moquegua). Several facies and compositional changes of Moquegua Group sediments, both along orogenic strike and through time, are already described; however, it lacks a detailed provenance study to constrain the tectonic and climatic controls on sediment generation, dispersal, and accumulation.

To do so sandstones from all Moquegua units from the three different sections have been sampled. Because it is crucial to know all the potential source rocks in some detail, the Proterozoic-Paleozoic basement, the Jurassic-Cretaceous sediments and the six different volcanic arcs (Chocolate, Toquepala, Tacaza, Huaylillas, Barroso and the frontal arc respectively from the oldest to the youngest) were sampled as well. The heavy mineral fraction has been separated for each potential source rock and the sediment samples. Single grain amphiboles and oxides have been used for geochemical analysis. Major elements from single grain amphiboles and oxides have been measured using the electron microprobe. The amount of trace elements from single grain amphiboles has been obtained using LA-ICPMS. Those two methods allow us to distinguish the different potential source rocks from each other and to define the sediment provenance for each member of the Moquegua Group, in each of the sections from N to S. Further thermochronological investigations, such as zircon fission track dating, will allow us to better constrain the uplift of the Central Andes.

Methodology for the determination of a precise regional geoid m odel in Argentina

Del Cogliano D 1 , Bagú D 1, Scheinert M 2, Dietrich R 2

1 Facultad de Ciencias Astronómicas y Geofísicas, Universidad Nacional de La Plata, Arge tina, dbagu@fcaglp.unlp.edu.ar

2 Institut für Planetare Geodäsie, Technische Universität Dresden, Germany

The geoid, defined by the Earth's gravity field, is a surface of equal gravitatio-nal potential. We can say that it represents the ideal ocean surface at rest, in the absence of tides and currents. A geoid model describes this special equipotential surface with respect to a mathematical reference surface, i.e. the ellipsoid. Precise geoid models are an important basis for a number of research fields in geoscien-ces including ge-

ophysics and oceanography. In geodesy, the geoid plays a fundamental role as reference surface for height systems. Orthometric heights can be de-termined without classic levelling by combining a geoid model and ellipsoidal heights derived from global navigation satell-te systems (GNSS) as the Global Positioning System (GPS). For this purpose, the importance of precise and high-resolving geoid models has increased in recent years, and an accuracy in the centimetre level is required. To achieve this goal, the combination of terrestrial and satellite information is necessary.

We present here the methodology for the computation of a precise geoid model for a large region in Argentina (lat 34°S to 39°S, long 58°W to 71°W) through the combination of different types of data as surface gravity observations, classical levelling data, GPS, satellite topography models and satellite Ear th gravity models. These different sources of information can be combined using the Remo-ve-Restore technique. At this, two different interpolation methods can be applied: the Least Square Collocation (Moritz, 1978) and the Equivalent Source Technique (Dampney, 1969; Del Cogliano and Introcaso, 2005).

For the anlysis of the gravity field, it is covenient to represent the geopotential functionals in spheri-cal harmonics and to employ the spectral analysis. Here, the long wavelengths of the spectrum can be represented by a global geopotential model while the short wa-velengths correspond to the effect of the regional topography. In our study, we use the global models EIGEN-5C (Förste et. al., 2008) and EGM2008 (Pavlis et. al., 2008). The SRTM3 digital elevation model (DEM) is used to account for the topo-graphy. Based on the global models and DEM's both the long and the short wave-length components of the gravity field are computed and it is possible to extract them ("remove") from the gravity data, obtaining residual values. These values are interpolated and a "residual" geoid is computed. Finally, the effects over the geoid of the global models and the topography are "restored" to this residual geoid.

For our region under investigation the modelled short- and long wavelength compo-nents of the geoid are presented and discussed. Our approach to the geoid deter-mination is demonstrated exemplarily.

References

Dampney C. (1969) The Equivalent Source Technique. Geophysics 34: 39-53

Del Cogliano D., Introcaso A. (2005) Gravity and GPS for geoid interpolation in Sierras de Tandil. Bollettino di Geodesia e Scienze Affini LXIV, N.3

Förste C., Flechtner F., Schmid R., Stubenvoll R., Rothacher M., Kusche J., Neumayer H., Biancale R., Lemoine J., Barthelmes F., Bruinsma S., König R., Meyer U. EIGEN-5C A new global combined high-resolution GRACE-based gravity field model of the GFZ-GRGS cooperation. Presented at the 2008 General Assembly of the European Geosciences Union, Vienna, Austria, April 13-18, 2008

Farr, T., et al. (2007) The Shuttle Radar Topography Mission. Rev. Geophys. 45 RG2004

Moritz H. (1978) Least Squares Collocation. Reviews of Geophysics and Space Physics 16 N°3: 27-36

Pavlis N., Holmes S., Kenyon S., Factor J. (2008) An Earth Gravitational Model to Degree 2160: EGM2008. Presented at the 2008 General Assembly of the European Geosciences Union, Vienna, Austria, April 13-18, 2008.

Magnetotelluric study of Parinacota and Lascar volcanoes

Diaz D , Brändlein D , Brasse H

Freie Universität Berlin, Fachrichtung Geophysik, Malteserstr. 74-100, 12249 Berlin, Germany, d.diaz@geophysik.fu-berlin.de

Electromagnetic methods allow to detect zones with different electrical properties. Among them, the magnetotelluric sounding method, with a large range of frequencies, allows to measure the electrical properties of rocks at considerable depths. In the study of volcanoes and hydrothermal systems, magnetotellurics has been widely used considering the different electrical properties expected in these structures, due to hydrothermal fluids, gas or melt in contrast with the surrounding rocks (see, e.g., Heise et al., 2008; Müller et al., 2004).

This investigation considers two regions of interest, the first one includes the zone around Parinacota (6362 m, 18°09'S, 69°08'W), a subduction related stratovolcano situated in the limit of Bolivia and Chile. The second zone is more to the south, around Lascar volcano (5592 m, 23°22'S, 67°44'W), located on the eastern side of the Salar de Atacama basin in northern Chile. It has been one of the most active volcanoes of the central Andes in the last years. Its recent activity is characterized by repetitive dome growth and subsidence, accompanied by degassing and explosive eruptions of various magnitudes (Pavez et al., 2006).

Data Acquisition: During October and November 2007, magnetotelluric and audio magnetotelluric sites were built in the area close to Lascar and Parinacota volcanoes. While the AMT data could reach periods between 0,01 to 1000 s, which is appropriate for a more shallow view, these sites were installed close to the volcanoes, the MT sites, which can reach longer periods and larger depths, were installed on a profile south of Lascar, and as an outer ring in the Parinacota region (Fig 1).

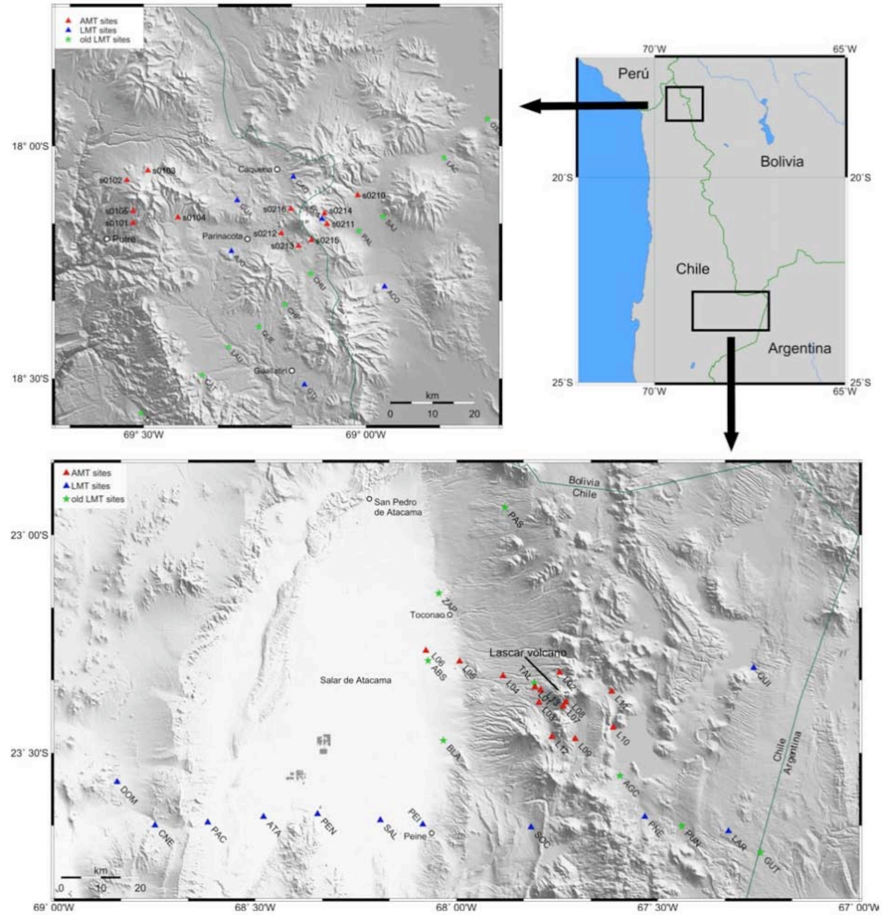


Figure 1. Study zone and measurement sites, top: Parinacota; bottom: Lascar.

Data Processing: To obtain the apparent resistivity curves from the time series, the real and imaginary parts of the impedance tensor were calculated with the robust Egbert processing program (Egbert, 2002). With this data, the first steps were to see the changes of the apparent resistivity with the period, the phase with the period, and also to calculate induction vectors and phase tensor ellipses.

Induction vectors are functions of the ratio of the vertical and horizontal components of the magnetic field, which in turn are functions of period and the horizontal resistivity gradient (Wiese, 1962). According to "Wiese convention", these vectors should point away from conductive zones.

The phase ellipse is a graphical representation of the phase tensor, which expresses how the phase relationships change with polarization, independent of the galvanic distortion produced by heterogeneities in the near surface (Caldwell et al. 2004).

Induction vectors and phase ellipses have been calculated for every measured period of the AMT sites, from 0.00391 s, as the lowest period, until 1024 s. From a first analysis of the apparent resistivity curves for the different sites, deep large conductive bodies seem to be absent in these zones. Besides this, topographic corrections have been developed for these zones.

Results: For the northern region, sensitivity models have been made, trying to answer the question of how big must be a magma chamber for be detectable with MT. With a magma chamber of 6,25 km3 placed at 8000 m under the volcanic edifice, it's possible to see a difference of around 1 % between the apparent resistivity of an halfspace with and without this magma chamber (with a resistivity contrast of 1000 by 1), considering the ring of AMT measuring sites close to Parinacota volcano (Figure 1). Two profiles were developed in the zone close to Lascar volcano. First profile is located in a W-NW direction in relation with Lascar volcano, and crossing the volcano to the SE. For this profile, a shallow conductive zone (2 km) under the volcanic edifice is present. A second profile, considering LMT data until 10000 s, is located some kilometers to the south of Lascar, crossing the Salar de Atacama and also the volcanic arc with an E-W direction and reaching the limit between Chile and Argentina. For this second profile, 2D inversion shows some of the principal features in the region, as the Salar de Atacama as a very conductive zone close to the surface, the Atacama Block under it and the precordillera as resistive bodies, the conductive zone related with the volcanic arc, and a large conductor under the Puna.

References

Caldwell T G, Bibby H M & Brown C (2004) The magnetotelluric phase tensor. Geophys J Intern 158: 457-469.

Egbert G D (2002) Processing and Interpretation of Electromagnetic Induction Array Data. Surveys in Geophysics, 23: 207-249.

Heise W, Caldwell T G, Bibby H M & Bannister S C (2008) Three-dimensional modeling of magnetotelluric data from the Rotokawa geothermal field, Taupo Volcanic Zone, New Zeland. Geophys J Intern doi:10.1111/j.1365-246X.2008.03737.x

Müller A, Haak V (2004) 3-D modeling of the deep electrical conductivity of Merapi volcano (Central Java): integrating magnetotellurics, induction vectors and the effect of steep topography. J Volcanol Geotherm Res 138: 205-222

Pavez A, Remy D, Bonvalot S, Diament M, Gabalda G, Froger J-L, Julien P, Legrand D & Moisset D (2006) Insight into ground deformations at Lascar volcano (Chile) from SAR interferometry, photogrammetry and GPS data: Implications on volcano dynamics and future space monitoring. Remote Sensing of Environment 100: 307-320.

Wiese H (1962) Geomagnetische Tiefentellurik Teil II: Die Streichrichtung der Untergrundstrukturen des Elektrischen Widerstandes, Erschlossen aus Geomagnetischen Variationen. Pure and Applied Geophysics, 52: 83-103.

Provenance of the Late Proterozoic to Early Cambrian metaclastic sediments of the Sierra de San Luis (Eastern Sierras Pampeanas) and the Cordillera Oriental, Argentina

Drobe M 1, López de Luchi M 2, Steenken A 3, Frei R 4, Naumann R 5, Siegesmund S 1, Wemmer K 1

1 GZG, University of Göttingen, mdrobe@gwdg.de
2 INGEIS, Ciudad Universitaria, Argentina
3 Institut für Geographie und Geologie, University of Greifswald, Germany
4 Inst. Geography and Geology/Nordic Center for Earth Evolution, Univ. of Copenhagen, Denmark
5 GFZ Potsdam, Germany

The geodynamic evolution of the southwestern margin of Gondwana, based on the geochemical and isotopic provenance studies of the (meta-) sediments, has been the focus of investigation for the last ten years in the Eastern Sierras Pampeanas and the Cordillera Oriental (Central and Northwestern Argentina, Sims et al. 1998; Rapela et al. 1998; López de Luchi et al. 2003; Bock et al. 2000; Brogioni 2001; Aceñolaza et al. 2002; Thomas et al. 2002; Thomas and Astini 2003; Schwartz and Gromet 2004; Steenken et al. 2004, 2006; Zimmermann 2005; Rapela et al. 2007; Escayola et al. 2007; Adams et al. 2008).

Provenance studies have been performed utilising major- and trace elements, Nd-systematics, whole rock Pb-Pb isotopes and zircon U/Pb SHRIMP data on metasedimentary rocks of the Sierra de San Luis (Nogolí Metamorphic Complex, Pringles Metamorphic Complex, Conlara Metamorphic Complex and San Luis Formation) and the Puncoviscana Formation of the Cordillera Oriental. The goal was the characterisation of the different basement domains in the study area and to give insights to the location of the source rocks. An active continental margin setting with typical composition of the upper continental crust is depicted for all the complexes using major- and trace elements. The Pringles Metamorphic Complex shows indications for crustal recycling, pointing to a bimodal provenance. Major volcanic input has to be rejected due to Th/Sc, Y/Ni and Cr/V ratios for all units. The $\varepsilon Nd(540Ma)$ data is lower for the San Luis Formation (-6.6 to -7.8) and higher for the Conlara Metamorphic Complex (-3.0 to -5.8), compared to the other units, in which a good consistency is given (basically between -5 and -6). This is similar to the T_{DM} ages, where the metapsammitic samples of the San Luis Formation are slightly older (around 1.8 Ga). The spread of data is largest for the Pringles Metamorphic Complex, again implying two different sources (1.83 to 1.64). The whole rock $^{207}Pb/^{206}Pb$ isotopic data lies in between the South American and African sources, excluding the Laurentian provenances. The whole rock Pb-Pb data is almost indistinguishable in the different investigated domains. Only the Pringles Metamorphic Complex shows slightly elevated $^{208}Pb/^{204}Pb$ values. Possible source rocks could be the Quebrada Choja in the Central Arequipa-Antofalla domain, the Southern do-

main of the Arequipa-Antofalla basement, the Brazilian shield or southern Africa. Zircon SHRIMP data point to a connection between the Puncoviscana Formation and the Conlara Metamorphic Complex. Two maxima around 600 Ma and around 1000 Ma have been determined. The Nogolí Metamorphic Complex and the Pringles Metamorphic Complex show one peak of detrital zircon ages around 550 Ma, and only a few grains are older than 700 Ma. The detrital zircon ages for the San Luis Formation show an age range between 590 and 550 Ma. A common basin can be assumed for the Conlara Metamorphic Complex and the Puncoviscana Formation. The available data support different sources for the rest of the Complexes of the Sierra de San Luis. These share the diminished importance or the lack of the Grenvillian detrital ages, a common feature for the Late Cambrian-Early Ordovician basins of the Sierras Pampeanas.

References

Aceñolaza F, Miller H, Toselli A (2002) Proterozoic-Early Paleozoic evolution in western South America – a discussion. Tectonopysics 354: 121-137

Adams C, Miller H, Toselli A (2008) Detrital Zircon U-Pb Ages of the Puncoviscana Formation Late Neoproterozoic-Early Cambrian of NW Argentina Provenance area and maximum Age of Deposition. VI SSAGI San Carlos de Bariloche - Argentina

Bock B, Bahlburg H, Wörner G, Zimmermann U (2000) Tracing crustal evolution in the southern central Andes from Late Precambrian to Permian with geochemical and Nd and Pb isotope data. Jour of Geol 108: 515–535

Brogioni M (2001) Geología de los cuerpos Vioroco y El Fierro, faja máfica-ultramáfica del borde oriental de la Sierra de San Luis. Rev de la Asoc Geol Arg 56 (3): 281-292.

Escayola M, Pimentel M, Armstrong R (2007) Neoproterozoic backarc basin: Sensitive high-resolution ion microprobe U-Pb and Sm-Nd isotopic evidence from the Eastern Pampean Ranges Argentina. Geol Soc Am 35 (6): 495-498

López De Luchi, M, Cerredo M, Siegesmund S, Steenken A, Wemmer K (2003) Provenance and tectonic setting of the protoliths of the Metamorphic Complexes of Sierra de San Luis. Rev de la Asoc Geol Arg 58 (4): 525-540

Rapela C, Pankhurst R, Casquet C, Baldo E, Saavedra J, Galindo C, Fanning C (1998) The Pampean Orogeny of the southern proto-Andes: Cambrian continental collision in the Sierras de Córdoba. In: Pankhurst R, Rapela C (Eds.) The Proto-Andean Margin of Gondwana. Geol Soc Lon Spec Pub 142: 181-217

Rapela C, Pankhurst R, Casquet C, Fanning C, Baldo E, Gonzáles-Casado J, Galindo C, Dahlquist J (2007) The Río de la Plata craton and the assembly of Gondwana. Earth-Sci Reviews 83: 49-82

Schwartz J, Gromet L (2004) Provenance of a Late Proterozoic-Early Cambrian basin Sierras de Córdoba Argentina. Prec Res 129: 1-21

Sims J, Ireland T, Camacho A, Lyons P, Pieters P, Skirrow R, Stuart-Smith P, Miró R (1998) U–Pb Th–Pb and Ar–Ar geochronology form the southern Sierras

Pampeanas: Implication for the Palaeozoic tectonic evolution of the western Gondwana margin. In: Pankhurst, R, Rapela C (Eds.) The Proto-Andean Margin of Gondwana. Geol Soc Lon Spec Pub 142: 259–281

Steenken A, López de Luchi M, Siegesmund S, Wemmer K, Pawlig S (2004) Crustal provenance and cooling of the basement complexes of the Sierra de San Luis: An insight into the tectonic history of the proto-Andean margin of Gondwana. Gond Res 7 (4): 1171-1195

Steenken A, Siegesmund S, López de Luchi M, Frei R, Wemmer K (2006) Neoproterozoic to Early Palaeozoic events in the Sierra de San Luis: Implications for the Famatinian geodynamics in the Eastern Sierras Pampeanas (Argentina). Jour Geo Soc 163: 965-982

Thomas W, Astini R (2003) Ordovician accretion of the Argentine Precordillera terrane to Gondwana: A review. Jour S Am Earth Sci 16: 67-79

Thomas W, Astini R, Bayona G (2002) Ordovician collision of the Argentine Precordillera with Gondwana independent of Laurentian Taconic Orogeny. Tectonophysics 345: 131-152

Zimmermann U (2005) Provenance studies of very low to low-grade metasedimentary rocks of the Puncoviscana complex northwest Argentina. In: Vaughan A, Leat P, Pankhurst R (Eds.) Terrane processes at the margin of Gondwana. Geol Soc Lon Spec Pub 246: 381–416

Ongoing seismological investigations around Villarrica Volcano, Southern Chile

Dzierma Y 1, Thorwar M 1, Rabbel W 1, Comte D 2, Legrand D 2, Bataille K 3, Iglesia P 4, Prezzi C 4

1 SFB 574, Christian-Albrechts-Universität zu Kiel, Germany
2 Universidad de Chile, Santiago, Chile
3 Universidad de Concepción, Concepción, Chile
4 Universidad de Buenos Aires, Argentina

As part of the collaborative research centre SFB 574, the Chilean subduction zone is being investigated by a seismological subproject conducted by Chilean, Argentinian and German partners. The general goal of the SFB 574 is to study the origin and influence of volatiles and fluids in subduction zones. The seismological subproject constitutes the structural and seismotectonic framework of these investigations.

In addition to presenting a continental end-member of subduction zones, seismicity and volcanism in the Chilean subduction zone are strongly influenced by sediment input into the trench, oblique convergence and strain partitioning, and pre-Andean characteristics of the overriding plate. Furthermore, the occurrence of the largest

instrumentally recorded earthquake, the Valdivia 1960 earthquake, close to the very active Villarrica volcano, makes this region ideally suited for subduction-related hazard investigations.

A network of 55 seismological stations was installed in November 2008 between 39 deg and 40 deg South. The stations are distributed from the coast to the back-arc in Argentina, linking Villarrica Volcano with the area of maximum coseismic slip of the 1960 Valdivia earthquake. The data collected by this network will serve for local and teleseismic tomography, seismicity, receiver function and anisotropy studies.

This poster will present first data examples. In addition to exploring the deep structure and geometry of the subduction zone, these studies will provide insight into the presence of fluids, fluid pathways, and the stress field. In combination with geochemical and volcanological studies also performed by the SFB 574, these investigations will contribute to a better understanding of subduction zone characteristics in a region of extreme coseismic stress, slab-arc fluid processes, volcano dynamics and hazards.

Geochronology of Late Cretaceous-Early Cenozoic magmatism in Northern Chile (24º30'–26º S)

Espinoza F 1, Cornejo P 1, Matthews S 2

1 Servicio Nacional de Geología y Minería, Av. Santa María 0104, Santiago, Chile, fespinoza@sernageomin.cl
2 Yamana Gold Inc., Santiago, Chile.

Introduction: In northern Chile, Late Cretaceous to Early Eocene magmatism is spatially constrained in a NS depressed corridor between the Coastal Cordillera batholith and the Andean Precordillera (Cordillera de Domeyko), in what is referred to as the Central Depression (Fig. 1). There, a series of basin-forming and basin-inversion events occurred during the Late Mesozoic and Early Cenozoic and are closely related to the magmatic history of the area. Several magmatic pulses have been recognized for this period (Puig et al., 1988; Marinovic et al., 1995; Cornejo et al., 2003) but its chronological limits are imprecisely known, inducing uncertainties in correlations between magmatic and tectonic events.

Geochronology: New Ar-Ar, K-Ar and U/Pb ages allow precise definition of magmatic pulses in the study area.

Upper Cretaceous rocks have been described by Cornejo et al. (2003) as basin-shoulder volcanic units, as they lie on both the eastern and western sides of NS-trending Upper Cretaceous basins and are contemporaneous with continental basin-filling units (not exposed in the study area). These depressions were later deformed and inverted

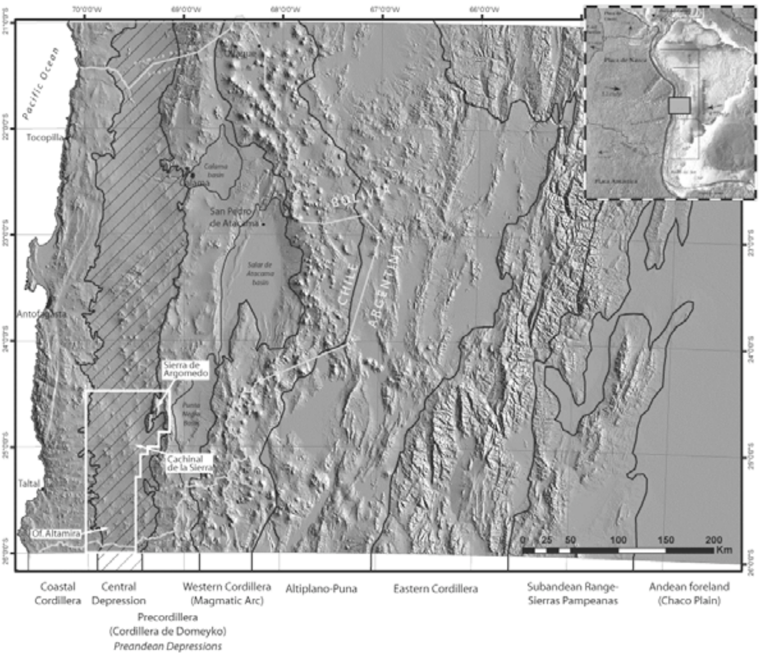


Figure 1: DEM SRTM image where the morphostructural units recognized in Northern Chile-Argentina-Bolivia are differentiated. Study area is shown by a rectangular white frame.

during a regional compressional event widely recognized in the region (65-62 Ma "KT" compressive deformation, Cornejo et al., 2003), as part of a tectonic regime dominated by shortening but punctuated by a period of extension (Cornejo and Matthews, 2001). In the study area this Late Cretaceous volcanism outcrops only in the areas surrounding the basin as crystal-rich quartz-sanidine rhyolitic ignimbrites; with the Los Trigos ignimbrite (75-71.55 Ma) overlying, with erosional unconformity, the Early Cretaceous Coastal batholith and Jurassic volcanic rocks on the west shoulder of the basin, and the Cachinal ignimbrite (71.2-69.3 Ma) overlying Jurassic marine beds to the east.

Lower Paleocene rocks (65.6-61.6 Ma) are limited in their distribution, and occur discordantly over Cretaceous rocks in the eastern border of a developing basin and related to the Soledad Fault System. East of Cerro Limbo, 64 Ma dacites lie unconformably over folded Upper Cretaceous ignimbrites dated at 73 Ma. Lithologies are mainly dacitic to andesitic lavas, breccias and domes, together with dacitic hornblende ignimbrites.

Middle Paleocene rocks are widespread over the entire study area, representing the most voluminous magmatic event. The major Sierra El Toro-Cerro Ballena ~NS ranges are formed by vitreous hornblende-biotite ignimbrites and domes, with ages

between 62.2-57.9 Ma, deposited discordantly over faulted Upper Cretaceous ignimbrites in the western border of the Paleogene basin, and related to the Catalina Fault System. Immediately north, the coeval Los Dorados mafic complex yields ages between 62.14-58.3 Ma. These basaltic rocks form a ring-like feature over contemporaneous ignimbrites and show textures suggesting shield-type blocky volcanism. East of Guanaco Mine, a pile of 60Ma rhyolitic ignimbrites is concordantly overlain by 58-57 Ma fine, dacitic lavas and domes. North of Cerro El Soldado, a dacitic lava-ignimbrite-dome sequence dated at 58.8-56.9Ma is tectonically tilted, evidencing deposition controlled by structures. In the foothills of the Sierra de Argomedo on the western side of the Cordillera de Domeyko (Fig. 1), ignimbrites dated at 58.8 Ma are overthrust by a sliver of basement rocks (Paleozoic granites, metasedimentary and metavolcanic rocks). The Cerro Buenos Aires, a pervasively altered dacitic dome and associated breccias, yield a U/Pb age of 59.9±0.4 Ma. In Cerro Cerrucho, gently folded volcanic breccias faulted against Upper Cretaceous ignimbrites have ages near 60 Ma.

Upper Paleocene sequences concentrate in the central part of the region. In the area of Cachinal de la Sierra (Fig. 1), voluminous andesitic-dacitic lavas and ignimbrites were dated at ~55 Ma; there, later rhyolitic domes (flow-banded rhyolites) extruded along NS-trending lineaments defining the western border of a volcanotectonic depression. Further north in the Sierra Peñafiel, several NW to NE lineaments together with a mayor western ring fracture define a semi-circular caldera-like depressed region (El Soldado Caldera); there hornblende-biotite-sanidine rhyolitic ignimbrites, domes and fine andesites yield ages also close to 55 Ma. Similar ages are also obtained from ignimbrites in the Cerros de Cebada area and in ignimbrites overthrust by west-verging reverse faults of the Cerros de Providencia Paleozoic block, ca. 15 and 30 km to the northeast, respectively. Furthermore, the same age is obtained for similar ignimbrites occurring between the uplifted Sierra de Argomedo Paleozoic block and the westward morphotectonic front of the Precordillera (Fig. 1). To the south, in Cerro Caupolicán and La Campana, the same lithofacies association is found, but ages are slightly younger at 55-52 Ma. In the Altamira area, the Cerro La Pólvora ignimbrites yields K-Ar ages of 56-55 Ma.

Lower to Middle Eocene rocks are sporadic, comprising minor effusions spilled discordantly over older sequences together with subvolcanic bodies and dykes intruding coeval rocks. Notably, a major volcanic sequence, the Cerro El Soldado lava sequence, dated at 52.7 Ma, lies unconformably (with onlap) over Upper Paleocene domes (ca. 55 Ma). In the area east of Oficina Catalina, several basaltic plateaus have Early Eocene ages (52-48.6 Ma), west of Guanaco Mine rhyolitic vitrophyres yield 51.6 Ma, and in the Inesperado district andesitic porphyries intruding coeval altered andesitic lavas were dated at 50.3-47.3 Ma. Middle Eocene ages were obtained in several basaltic flows (43.9 Ma) and in a porphyry intruding close to the western frontal thrust of the Precordillera (40.9-39.7 Ma). To the southeast, mafic to inter-

mediate lavas and intrusions form the Pampa Rubia and Pampa Lorca volcanic complexes, with ages ranging between 57-50 and 46-43 Ma, respectively.

Discussion and conclusions: Five known magmatic events have been chronologically defined and described: Late Upper Cretaceous, Lower Paleocene, Middle Paleocene, Upper Paleocene and Eocene. The obtained ages indicate that magmatism occurred closely related with regional and/or local tectonism.

The Upper Cretaceous Los Trigos ignimbrite (75-73 Ma) lies subhorizontally in the western border of a Cretaceous volcanotectonic depression and has an exposure area of >367 km^2; while to the east, the Cachinal ignimbrite is intensely folded and yield younger ages of 71-69 Ma with an outcrop exposure area of 35 km^2. Ages, spatial distribution, thickness differences, welding patterns, as well as deformation suggest an origin for the ignimbrites by a trapdoor-like caldera eruption. Thick extra-caldera ignimbrites (Los Trigos) were deposited over the crystalline basement, which avoided KT deformation; and a thinner intra-caldera sequence (Cachinal ignimbrite) was deposited over incompetent Jurassic marine beds, absorbing considerable deformation that was canalized along caldera axe through collapse faults.

Afterwards, a period of tectonic relaxation drove extension and Early Cenozoic magmatism ascended through the crust using reactivated high-angle, basin-bounding faults as conduits. Lower Paleocene ages (63-60 Ma) indicate that magmas were partially syntectonically extruded, which may be the cause for the reduced volume of this event and its occurrence only close to the tectonic eastern border of the Cretaceous basin. In addition, lavas were deposited discordantly over folded and eroded Upper Cretaceous ignimbrites, indicating also post-tectonic magmatism.

Detailed Ar-Ar age determinations in the El Toro-Cerro Ballena ranges allow assigning this sequence to the Middle Paleocene, then postdating the KT compression (not being syntectonic as originally inferred by Cornejo et al. 2003), consistent with the development of a new extensional tectonic regime in which voluminous caldera-related deposits accumulated close to the western tectonic border of the basin. The Upper Paleocene eruption of the El Soldado Caldera sequence is now better constrained in space and time, reaching a minimum exposed area (ignimbrites, lavas and breccias) of ca. 163 km^2 extruded in less than ~1 My. The semicircular geometry and the presence in the middle of the depression of an uplifted and tilted block made of dacitic breccias and lavas (U/Pb 54.0 ± 0.9 Ma) suggest a trapdoor-like eruption and resurgence of the caldera floor. The occurrence of 55 Ma ignimbrites overthrust by Paleozoic rocks in the Sierra de Argomedo gives a maximum age for the initiation of a series of compressive tectonic events of increasing intensity that ended with the development of the Incaic deformation phase (~ 45-37 Ma; Tomlinson et al., 1993). Pre-Incaic (55-45 Ma) compressive deformation produced minor faulting and folding of the Upper Paleocene to Lower Eocene sequences, and has also been recognized south of the study area (Inca de Oro sheet, Matthews et al., 2006; Matthews and Cornejo, 2004). Magmatism during this period includes volcanic and subvolcanic products. Later, minor Middle Eocene "Incaic" mafic volcanism

occurred randomly in the entire area in close association with preexisting structures, and plutonism concentrated along the pre-cordilleran Domeyko Fault System.

The two major compressive events (Lowest Paleocene and Middle Eocene) known for northern Chile are recognized in the study area. Magmatic pulses occurred closely related to tectonism, mostly along ~NS regional structures; while small-volume, mainly mafic volcanism and plutonism is recognized during periods of compression, and high-volume intermediate to felsic volcanism was generated between compressional events when tectonic relaxation (minor extension) occurred (Upper Cretaceous and Middle-Upper Paleocene). The petrology and geochemistry of rocks also varies in direct response to changing tectonic conditions, as has also been shown for the Inca de Oro-El Salvador area to the south (Cornejo and Matthews, 2004), which is in turn directly related to paleogeodynamics (see Pardo-Casas and Molnar, 1987).

References

Cornejo P, Matthews S, Pérez de Arce C (2003) The "K-T" compressive deformation event in northern Chile (24-27ºS). X Congreso Geológico Chileno, Extended Abstracts Volume (CD), Concepción.

Cornejo, P. and Matthews, S. 2001. Evolution of magmatism from the Uppermost Cretaceous to Oligocene, and its relationship to changing tectonic regime, in the Inca De Oro-El Salvador area (Northern Chile). *In* III South American Symposium on Isotope Geology, Pucón, Chile.

Marinovic N, Smoje I, Hervé M, Mpodozis C (1995) Hoja Aguas Blancas. Servicio Nacional de Geología y Minería, Carta Geológica de Chile, No. 70, 150 p., 1 mapa escala 1:250.000. Santiago.

Matthews, S. and Cornejo, P. 2004. Middle to Late Eocene high-sulphidation Cu-Au vein mineralization at Guanaco Mine and Cerro Inesperado, II Region, Chile. *In* International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) General Assembly, Pucón, Chile.

Matthews, S.; Cornejo, P.; Riquelme, R. 2006. Carta Inca de Oro, Región de Atacama. Servicio Nacional de Geología y Minería, Carta Geológica de Chile, Serie Geología Básica, Nº 102, 1 mapa escala 1:100.000.

Pardo-Casas, F. and Molnar, P. 1987. Relative motion of the Nazca (Farallón) and South American Plates since Late Cretaceous time. Tectonics 6: 233– 248.

Puig A, Diaz S, Cuitiño L (1988) Sistemas hidrotermales asociados a calderas en el arco volcánico paleoceno de la Región de Antofagasta, Chile. Distritos Cachinal de la Sierra y El Soldado. Revista Geológica de Chile 15: 57-82.

Tomlinson AJ, Mpodozis C, Cornejo P, Ramírez CF (1993) Structural geology of the Sierra Castillo-Agua Amarga fault system, Precordillera of Chile, El Salvador-Potrerillos. Proceedings, II International Symposium on Andean Geodynamics, Oxford, UK: 259-262. Orstom éditions, Paris.

SHRIMP U-Pb dating and subsidence analysis of pre-Andean Paganzo Basin, northwestern Argentina: Implications for late Paleozoic tectonic evolution of western Gondwana.

Ezpeleta M 1, Astini RA 1, Dávila FM 1, Cawood P 1

1 LAC Universidad Nacional de Córdoba, Argentinamezpeleta@efn.uncor.edu
2 University of Western Australia, Australia.

The Upper Paleozoic basins of western Argentina have been extensively studied since the earliest twentieth century from a sedimentological-stratigraphic and biostratigraphic point of view. Nevertheless, the tectonic setting is still debated. These basins have been considered from pure extensional systems (e.g. Salfity and Gorustovich, 1983) and pull-apart basin (Fernández Seveso and Tankard, 1995), to flexural forelands generated by tectonic loading (e.g. López Gamundí et al., 1994; Ramos, 2000). In order to contribute to understand the evolution of these Carboniferous-Permian basins, we carry out a provenance study using U-Pb SHRIMP detrital zircon dating and complementary subsidence analyses. These data together to previous sedimentological and stratigraphic information assist us to unravel the tectonic scenario of the Gondwanan basins along west-central Argentina.

The stratigraphy can be separated into two different regions, the western depocenter between the Cordillera and the western Sierras Pampeanas and the central-east depocenter located within the eastern Sierras Pampeanas. The western depocenters are formed, from bottom to top, by the Punta del Agua, Río del Peñón and Mulas Muertas Fms, and the central-eastern depocenters by the Malanzán, Las Pircas and De la Cuesta Fms.

From the U-Pb detrital zircon ages (<10% discordant), we differentiate major age peaks as follows: In the western region of the basin, 337 ±17 (n=3), 1060 ±25 (n=7), 1195 ±82 (n=3), and 1375 ±62 (n=4) Ma for Punta del Agua Fm and 471 ±12(n=5), 509.8±8.2 (n=2) 547.3±5.8 (n=3), 570±18 (n=5), 1020±43 (n=7) and 1195 ±52 (n=6) Ma for Río del Peñón Fm. In the eastern basins: 365 ±27 Ma, (n=2), 471 ±19 Ma, (n=3), 522 ±28 Ma, (n=2) and 1138 ±110 (n=3) Ma for the Malanzán Fm; 457,2 ± 9 (n=9) for the Las Pircas Fm; and 481 ±23, (n=2), 1050 ±60 (n=6) Ma for the De la Cuesta Fm.

In the western depocenter, the youngest zircon ages in the volcaniclastic Punta del Agua Fm (ca. 337 Ma, late Mississipian) are interpreted as autochthonous related to recycling of andesitic and acidic flows in the same unit. These ages are similar to those of volcanic rocks in the southern Puna (ca. 334 Ma., Martina et al., 2007) immediately to the northeast. The Mesoproterozoic detrital input is more consistent with a provenance from the basement highs (presently western Sierras Pampeanas assumed to be part of the large Cuyania terrane), immediately to the east-southeast. Paleocurrent and composition of granitic conglomerates interfingering with volcanic deposits indicate a provenance from Sierras Pampeanas at the east.

In the eastern depocenter, the zircon ages of early Pennsylvanian glacial deposits (Malanzán Fm), indicate that these deposits are a local cover for the eastern Sierras Pampeanas, including a Cambrian basement (recycling Mesoproterozoic ages) intruded by Ordovician and late Devonian granites. Paleocurrents and composition of conglomerates support a provenance mainly from the east.

During late Pennsylvanian- early Permian, an important postglacial transgression took place in the basins of western Argentina. Conglomeratic wedges of the Las Pircas Fm in the eastern domain and fluvial-deltaic sequence of the Río del Peñón Fm in the western domain, show Ordovician, Cambrian, Neoproterozoic and Mesoproterozoic detrital inputs that indicate a provenance from the Sierras Pampeanas. Paleocurrent and composition are consistent with such provenance suggesting a depositional continuity between these two units.

Early Permian recurrence of alluvial-fluvial-ephemeral lakes indicates a definite continental setting for Paganzo Basin. In the eastern-central domain, Ordovician detrital ages in the De la Cuesta Fm are consistent with the onlapping relationship with the Ordovician granites that have been the local source. The lack of Cambrian and Neoproterozoic ages together with a major Mesoproterozoic population suggest a western provenance (western Sierras Pampeanas) where the host of Ordovician granites are Grenville rocks. By contrast to the east, the host of Ordovician granitic plutons yields important Cambrian and Neoproterozoic ages (Collo et al., 2009).

The paleogeographic reconstruction allows to interpret that during the late Mississipian-early Permian, the regional slope of the Paganzo Basin is from the Pampean Ranges at the east toward the current Cordillera. The continentalization of the basin during the Permian, is associated with the inversion of the regional slope toward the east.

From the analysis of the cummulative subsidence curve two different stages arise. The first stage is better explained by lithospheric stretching as indicated by the large and rapid amount of subsidence. The second stage is more common of flexural basins, driven by increasing tectonic loads indicated from the exponential arrangement. This later foreland stage is coeval with the occurrence of arc volcanism and plutonism of the Choiyoi Complex, exposed in the Cordillera to the west. The flattening of the subsidence curve between both stages would represent a sag interval and local unconformities developed during the Early Permian.

The provenance analysis together with our new subsidence curve suggest the late Paleozoic Paganzo basin was formed in two stages: (a) a backarc extensional basin system with a major detrital supply (extrabasinal) from the east and intense intrabasinal volcanism, and b) a flexural foreland system with provenance from the Cordillera and progradation of clastic systems toward the east, similar to the modern Andean foreland.

References

Collo, G.; Astini, R.A.; Cawood, P.A.; Buchan, C.; Pimentel, M. 2009. U-Pb detrital

zircon ages and Sm-Nd isotopic features in low grade metasedimentary rocks of the Famatinian belt: implications for late Neoproterozoic-early Paleozoic evolution of proto-Andean margin of gondwana. J Geol Soc 166: 1-17.
Fernández-Seveso, F.; Tankard, A. 1995. Tectonics and stratigraphy of the Late Paleozoic Paganzo Basin of Western Argentina and its regional implications. In: Petroleum basins of South America (Tankard, A. J.; Suarez, S.; Welsink, H.J.: editores). American Association of Petroleum Geologists Memoir 62: 285-301.
López Gamundí, O.R.; Espejo, I.S.; Conhagan, P.J.; Powell, P.J. 1994. Southern South America. In: Permian-Triassic Pangean Basins and foldbelts along the Panthalassan margin of Gondwanaland (Veevers J.J.; Powell C., editors), Geological Society of America Memoir 184: 281-329. Boulder.
Martina, F.; Viramonte, J.M.; Astini, R.A.; Pimentel, M.M.; Dantas, E., 2007. Evidence of Early Carboniferous Pre-Choiyoi volcanism in western Gondwana: first isotopic, geochemical and U-Pb SHRIMP data. XX Colloquium on Latin America Earth Sciences, Abstract, pag. 51. Kiel, Alemania.
Mpodozis, C.; Kay, S.M. 1990. Provincias magmáticas ácidas y evolución tectónica de Gondwana, Andes chilenos (28º-31º S). Revista Geol Chile 17: 153-180.
Ramos, V.A. 2000. The Southern Central Andes. In: Tectonic Evolution of South America. 31st. International Geological Congress America (Cordani, U.G.; Milani, E.J.; Thomaz Filho, A.; Campos, D.A.; editors). Fólio Produção Editorial, Gráfica e Programação Visual: 561-604. Río de Janeiro.
Salfity, J.A.; Gorustovich S.A. 1983. Paleogeografía de la cuenca del Grupo Paganzo (Paleozozico Superior). Revista de la Asociación Geológica Argentina 38(3-4): 437-453.

The Late Devonian glaciation in western Argentina: expanding the frontiers of Gondwanan glacial epoch

Ezpeleta M , Astini RA

LAC Universidad Nacional de Córdoba, Argentina, mezpeleta@efn.uncor.edu

Unquestionable Devonian glacial record has not been documented in Argentina. The absence of Upper Devonian – Lower Carboniferous deposits has been attributed to tectonic causes, linked with the collision of Chilenia Terrane along the Gondwana margin, or to the combined action of tectonism and glaciation during the late Early Carboniferous. In the Las Minitas Ranges, northern Precordillera, a notable record of diamictites within a strongly folded marine sequence (Jagüel Formation) is recorded. Bimodal igneous rocks bracketed Late Devonian-Early Carboniferous (Ar-Ar ages ca. 346-364 Ma, Coughlin 2000), where folded together with these rocks and both have been truncated in angular unconformity before deposition of Late Carboniferous deltaic systems (Río del Peñón Formation). Devonian trilobites recorded

elsewhere in the Precordillera and associated brachiopod and bivalve faunas occur below and above this interval and certifie the Devonian age of the interval.

Gray-greenish massive and stratified diamictites and pebbly mudstones (~70 m) including a variety of suspended boulders, are sharply overlain by a well stratified interval of bioturbated silty shales and graded beds yielding marine faunas. Diamictites possess a massive and meter scale interval at the base with subtle textural changes and different concentrations of suspended clasts inside the matrix (Dmm). Suspended subrounded to subangular blocks (> 1m) yield polished and striated surfaces. Well rounded boulders with flattened faces (flat-iron) or bullet-shapes are also common. All these features indicate that the sediment was partly involved within the subglacial load . Stratified diamictites (Dms), interbedded with the Dmm develop as interbedded intervals. Dms show fine-grained partings and contain abundant dropstones that commonly exceed bed thickness. The facies may be indicating water-lain processes where thin fine-grained partings are the product of residual settling after more massive rain out. Oversized clasts are clearly dropstones and show impact associated structures. Facies association also contain intervals (<2.5 m) of laminated mudstones with dispersed dropstones and sandy intervals (1.5 m) composed by groupings of tabular graded to massive layers separated by thoroughly bioturbaded mud partitions. Internal features are compatible with gravity flows (turbidity current deposits). Some of the sandy beds show subtle coarser grains on the top or pebble concentrations indicating winowing effects and rework by diluted bottom currents.

Diamictites are locally involved within slumped and folded intervals (~17 m) linked with coherent flow processes (flow tills?). Clast composition is dominated by highly compacted sandstones, limestones, and basic rocks derived from underlying Ordovician units cropping in the nearby region. These compositions clearly differ from Nammurian diamictites where high-grade metamorphic rocks and granitic boulders are dominant.

Paleontological and geochronological record allow constraining this glaciomarine sequence to Late Devonian and contribute to separate this glacial record from the overlying Río del Peñón Formation recording the Nammurian glaciation, immediately above the angular unconformity. The deformation and the bimodal igneous dykes that affect the Devonian record do not affect the Río del Peñón Formation, indicating an important tectonic event also explaining the angular unconformity between both.

Glacial tillite included in the Jagüel Formation allows expanding the area covered by the Late Devonian Glaciation in South America, previously recorded in Brasil and along the Central Andes.

References

Coughlin, T.J., 2000. Linked origen-oblique fault zones in the central Argentine Andes: the basis for a new model for Andean orogenesis and metallogenesis. Ms Thesis (unpublished), Queensland University, Australia, 207 pp.

Plan der ordenamento terretorial del distrito de Paraguarí, República del Paraguay Trabajos en el Marco del proyecto de Ordenamiento Ambiental de Zonas Urbanas (ORDAZUR), convenio de Cooperación SEAM-BGR

Fariña D 1, Morel A 2, Pasig R 3

1 Director de Ordenamiento Territorial / SEAM, farina@ordazur.org
2 Directora General de Gestión Ambiental (DGGA) / SEAM, anamorels@gmail.com
3 Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Hannover, Ronald.Pasig@bgr.de

La Secretaría del Ambiente de Paraguay (SEAM-Py) es la institución responsable a nivel nacional de realizar e implementar los Planes de Ordenamiento Ambiental del Territorio (POAT). Estos son desarrollados y ejecutados en forma conjunta y coordinada entre la SEAM y los gobiernos regionales (municipios y gobernaciones). A efectos de poder normar el ordenamiento territorial, la SEAM ha puesto a consideración del Consejo Nacional del Medioambiente (CONAM) en el año 2005, un anteproyecto de Ley de Ordenamiento Ambiental del Territorio. Esta ley se encuentra actualmente sujeto a revisión y consenso.

Como su definición lo indica, el Plan de Ordenamiento Ambiental del Territorio es una herramienta que regula el uso de espacio físico, teniendo en cuenta criterios ambientales y definiendo para ello los usos posibles y más apropiados de las diversas áreas en que se ha zonificado el territorio. En este contexto se ejecuta el proyecto Ordenamiento Ambiental de Zonas Urbanas (ORDAZUR, fase 2). Llevado a cabo por la Secretaría del Ambiente de Paraguay (SEAM), con el apoyo técnico y financiero del Instituto Federal de Geociencias y Recursos Naturales (Bundesanstalt für Geowissenschaften und Rohstoffe-BGR) y el Ministerio de Cooperación Económica y Desarrollo (Bundesministerium für Wirtschaftle Zusammenarbeit und Entwicklung-BMZ) de Alemania. Las actividades se ejecutan en estrecha cooperación con municipios y gobernaciones preseleccionados, que posteriormente son los directos responsables de ejecutar el plan.

Una de las intervenciones pilotos corresponde al proyecto de Ordenamiento Ambiental del Territorio del área urbana del municipio de Paraguarí. El municipio de Paraguarí se ubica en la región Oriental del Paraguay, distante a unos 66 kilómetros de la ciudad de Asunción, capital de la república del Paraguay. Cuenta con una población urbana estable de 8.307 habitantes según el Censo Poblacional 2002 y lo componen 16 barrios, sobre una superficie total de 462 Km2. Sobre este distrito se están ejecutado los trabajos para la elaboración del POTA y que constan de:

a) Relevamiento e interpretación de la información existente. Para esta actividad se ha verificado y analizado la siguiente información del distrito:

• Datos Socioeconómicos (población, vivienda, grado de desarrollo, etc.)
• Datos catastrales (definición de zona urbana y rural)
• Uso actual y potencial del suelo
• Datos geológicos, edafológicos, topográficos, hidrológicos, vegetación y geomor-

fológicos
• Proyectos existentes, de manera tal de incluir las recomendaciones del POTA en las políticas de desarrollo nacionales y departamentales

b) Relevamiento e interpretación de información nueva de base. Para estos trabajos se han utilizado modernas herramientas de interpretación mediante Sistemas de Información Geográfica (SIG), utilizando imágenes actuales de alta resolución (Ikonos), como así también trabajos complementarios de campo. Algunas tareas que han demandado mayor detalle en su análisis han sido:
• Ubicación de un sitio apto para el Relleno Sanitario
Para su la ubicación de este sitio se ha utilizado la norma para la ubicación de sitios de rellenos sanitarios vigente en la SEAM (Resolución N° 282/04). Una vez ubicado los sitios potenciales, se han realizado una serie de trabajos de campo, de manera tal de verificar se aptitud. Algunos de los más significativos han sido:
• Relevamiento geológico / topográfico de detalle
• Relevamiento de suelos a través de sondeos y análisis de laboratorio.
• Análisis granulométrico y determinación de permeabilidad del suelo. Determinación de barreras geológicas
• Estudios geofísicos (geoeléctricos) de detalle
NOTA: En el POSTER a presentar se informará acerca de los alcances y resultados arribados con los estudios de ubicación del Relleno Sanitario
• Ubicación de áreas de reserva o de interés histórico
• Delimitación del área urbana y rural del distrito
• Relevamiento de la calidad de los recursos hídricos superficiales y subterráneos
NOTA: En el POSTER a presentar se informará acerca de los alcances y resultados alcanzados con estos estudios de calidad de las aguas superficiales y subterráneas. Complementariamente se está trabajando en talleres participativos con la población del distrito, de manera tal de fijar indicadores para definir la situación existente y deseada para su comunidad. También se ha apoyado a la municipalidad de Paraguarí en la implementación de la Unidad de Medio Ambiente, la cual cuenta con las capacidades humanas y técnicas para desarrollar sus funciones.

Progress of the Application of GIS on Georisks in Central America

Feldhaus L 1, Castellón A 3, Palucho R 1, León X 2, Funes G 5, Strauch W 1

1 Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Project on the Mitigation of Disasters in Central America, Managua, Nicaragua, ludwig.feldhaus@bgr.de

2 Instituto Nicaragüense de Estudios Territoriales (INETER), alex.castellón@gf.ineter.gob.ni

3 Servicio Nacional de Estudios Territoriales (SNET), San Salvador, El Salvador

4 Instituto Nacional de Sismología, Vulcanología, Meteorología e Hidrología (INSIVUMEH), Guatemala
5 Comisión Permanente de Contingencias (COPECO), Tegucigalpa, Honduras

In the last years, multiple efforts were undertaken to prevent or mitigate the negative effects of natural phenomena to the population in Central America. National and local authorities have become more involved in disaster prevention policy and international cooperation boosted funding for disaster prevention and mitigation measures in the region. Multiple hazard mapping projects were conducted by local geoscientific institutions and international partners. Universities, NGO´s, Agencies for international technical assistance, and foreign scientific groups cooperate to capacitate the local geoscientists and to improve higher education on disaster prevention.

In Nicaragua, this development was possibly most pronounced. To manage and use the data in an efficient way a comprehensive GIS on Georisks in Nicaragua was envisioned since 1999 and developed since 2002 at Instituto Nicaragüense de Estudios Territoriales (INETER, Nicaragua) in cooperation with Bundesanstalt für Geowissenschaften und Rohstoffe (BGR, Germany). This GIS includes extensive topographical coverage and large part of the data obtained by many recent projects on natural hazard, vulnerability and risk. It contains numerous data on elements under risk; for instance, cadastre data of several cities. The GIS was integrated with INETER´s monitoring and early warning systems; certain parts of the data base are updated continuously and in real time and high quality maps can be provided in near real time; e.g. on seismic events, strong rain falls, volcanic phenomena. The GIS is used routinely at INETER and GIS data were provided to multiple new projects on georisks in Nicaragua which after their termination return their products to the system to assure its continuous growth. Local universities, governmental institutions, NGO´s make use of the GIS data base. Examples of datasets are: seismicity of Nicaragua (30,000 events), landslide coverage (17,000 events), seismic vulnerability of Managua (212,000 buildings), seismic microzonation data of several towns, hazard and vulnerability data for 30 municipalities in Western Nicaragua, hazard assessments using GIS for 90+ social house building projects (7000 families benefitted), tsunami hazard and early warning for the Nicaraguan Pacific coast. An interdisciplinary group of geoscientists, informatics engineers and GIS specialists at INETER was trained to develop and use GIS in their daily work. Web mapping services based on ESRI´s ArcIMS are published on INETER´s website to provide the public with direct access to some of the data.

Based on the experience in Nicaragua similar GIS are developed in El Salvador, Guatemala and Honduras and the cooperation between these countries is promoted.

In El Salvador, a new geosciences institution was founded one year after the disastrous earthquakes which shook the country in 2001. The Servicio Nacional de Estudios Territorales (SNET) was formed to some extend on the model of INETER in Nicaragua. In the first years, the assessments of the earthquake affectations were important tasks of the new institution. GIS played an important role in

this work. In 2004 SNET started cooperating in the regional project developed by BGR on the Mitigation of Georisks in Central America. The small GIS unit of SNET demonstrated their efficiency in the organization of the GIS and the production maps on seismic and volcano hazard, landslide susceptibility and aspects of vulnerability and risk. A very successful approach of SNET was the development of Web mapping services based on open Web server technology what helped to assure the high quality and interesting content of the website of the institution.

In Guatemala, GIS on Georisks developed in two institutions. Different to the situation in Nicaragua and El Salvador where mapping and GIS on natural hazards are concentrated in the national geosciences institutions, in Guatemala a considerable scientific expertise exists also in CONRED, the Coordinating Agency on Disaster Prevention. Thus, there are now two GIS units cooperating with BGR and institutions from neighboring countries to develop a National GIS on Georisks. One is already working at CONRED mainly oriented towards monitoring, early warning and emergency management and the other was initiated recently at Instituto Nacional de Sismología, Vulcanología, Meteorología e Hidrología (Geosciences institute, INSIVUMEH). At INSIVUMEH, a data base was build up, first GIS applications were elaborated, and there are good prospects for an efficient National GIS system on Georisks.

In Honduras, there exists, unfortunately, no centralized geosciences institution. COPECO the Honduran Emergency commission, tried to establish a GIS system in their headquartes. BGR and the cooperating geosciences institutions in the neighboring countries were trying boost this development. Data from many sources were collected and inventory was elaborated, but, due to the lack of scientific personnel at COPECO, the progress in the establishment of a GIS and the use of the data remained slow. Lately, COPECO succeeded to obtain the supervision of a development program on hazard mapping funded by World Bank which works already since 2002 in the country and elaborated hazard and susceptibility and vulnerability coverage and maps for dozens of municipalities in the country. It is hoped that the technical personnel working in this program can now provide the critical mass to establish a permanent Unit for a GIS on Georisks at COPECO which can also cooperate efficiently with national institutions as University of Honduras and with BGR and the geosciences institutions in the other Central American countries.

To develop cooperation between the countries on the application of GIS for the assessment of Georisks two pilot areas were defined be two or several countries work together. The TRIFINIO is such a zone where Guatemala, El Salvador and Honduras have common borders and where natural phenomena may affect two or three countries at a time. The Commission of the Trifinium installed by the three governments on the base of an international agreement has deployed a GIS group at its Technical Unit in Esquipulas, Guatemala. Disaster prevention is an important topic of this unit. Since 2007 the Trifinio-Project, INSIVUMEH, SNET, COPECO, INETER, and BGR have joined capacities to create a geological map of the area, to analyze landslide susceptibility for all the area of the TRIFINIO and to assess the

seismic hazard for Esquipulas, the main city of the area. The institutions will provide the TRIFINIO with relevant GIS coverage to assure that all the necessary data for disaster prevention and mitigation.

Another multinational effort is going on to create tsunami hazard maps for the Gulf of Fonseca a large bay of the Pacific Ocean shared by El Salvador, Honduras and Nicaragua. The coasts of the Gulf are endangered by tsunamis generated by local, regional and distant earthquakes and local volcanic eruptions. Since 2008, a work is going on where INETER, SNET, COPECO and BGR cooperate to establish high resolution tsunami hazard maps based on long lasting experiences gained by INETER in Nicaragua.

The rapid information on dangerous events and early warning systems are other fields of ongoing cooperation between Central American countries promoted by BGR. GIS is used for the rapid information on possible effects of seismic events and a software system was developed to present in near real time estimates for strong precipitation which may contribute to early warning on landslides triggered by strong and long lasting rainfalls. First experiences are positive and works are going on to validate rain estimates to develop local threshold curves for landslide sites in Central America.

Tectonic evolution of the Southern Central and Northern Patagonian Andes (34º30´- 43º30´S)

Folguera A, Rojas Vera E, Spagnuolo M, García Morabito E, Orts D, Bottesi G, Ramos VA

Laboratorio de Tectónica Andina. Universidad de Buenos Aires, andresfolguera2@yahoo.com.ar

A big controversy still exists in relation to the temporal definition of main contractional phases that had led to the construction of the Southern Central and Northern Patagonian Andes since the early works of Groeber (1929): How many phases have coexisted spatially? What is the real extent for each phase and therefore their relative importance? What is the relationship between the phases of Andean construction and the behavior of the volcanic arc through time as indicative of potential geometry of the subducted slab? Have these contractional stages been followed by gravitational disequilibria?

The western sector of the Andes at these latitudes between the Central Valley in Chile and the drainage divide area is formed by an inverted Late Oligocene to Early Miocene basin (25-18 Ma) named the Cura Mallín basin. Two main phases have led to the closure of this basin ca. 17-18 Ma constrained by fission track data at the western slope of the Andes and ca. 12-9 Ma respectively (Burns, 2002). Synorogenic deposits associated with this early phase of contraction have by-passed a highly eroded Cretaceous to Eocene fold and thrust belt, being deposited at the Río

Grande basin off the Late Miocene orogenic front since 18 Ma (Silvestro and Atencio, 2008). Older contractional deformations in the area have defined two orogenic fronts constrained by unconformities: i) a Late Cretaceous orogenic front (100-65 Ma) east of the Cura Mallín basin, evidenced by an unconformity between Paleogene successions and the Cretaceous deposits, which marks the maximum advance of latest Cretaceous to Paleocene marine-Atlantic transgression in the area, constrained by fission track ages at the Cordillera del Viento (Burns, 2002) and the Chihuidos uplift (Zamora Valcarce et al., 2008). This orogenic phase has been associated with synorogenic deposits corresponding to the Neuquén Group, locally containing synorogenic unconformities, presently cannibalized by Neogene structures at the inner part of the fold and thrust belt and buried beneath Neogene sequences at the Río Grande basin. These sequences contain a first input of Late Cretaceous detrital zircons through the entire Mesozoic column that indicates incipient exhumation of the arc located to the west (Ramos et al., 2008). And ii) a Late Eocene orogenic front, evidenced by an unconformity between Oligocene and Eocene strata, developed east of the Río Grande Neogene foreland basin, associated with synorogenic sequences of the Pircala Formation. Late Cretaceous to Late Eocene deformations can be taken as two end limits of a first wave of contractional deformation affecting the western border of the continent at these latitudes. After that an extensional event created the Cura Mallín Basin superimposed to the Late Cretaceous thrust fan and the Palaoco Basin at the Late Eocene orogenic front. These extensional structures were finally inverted around 17-18 Ma. Both contractional phases of deformation correlate spatially and temporally with two eastward arc expansions that covered parts of the eastern slope of the Andes at these latitudes.

During last years increasing evidence about the inception of shallow subduction regimes has been revealed as decisive factors in constructing Andean relief. These are revealed by i) extreme outward expansion of arc-related sequences followed by ii) periods of crustal thickening, and iii) subsequent location of the arc-front nearer to the trench, coexisting with iv) extensional collapse. Extensional depocenters created at stage iv), controlled the emplacement of both mantle derived materials and crustal melts. Particularly, initial stages in Andean deformation along the western margin of the Southern Central and Northern Patagonian Andes (36°-43°30´S) are associated with previous eastward-arc expansions. Those can be associated with two discrete shallow subduction regimes: Eastward expansion of Late Cretaceous to Eocene (75-45 Ma) arc-related sequences (36°-43°30´S) that describe two separate lobules centered at 36°-39ºS and 40°-43°30´S respectively, where arc migration was maximum with values around 400 km. Both correlate with Late Oligocene to Early Miocene intraplate volcanic plateaus at the outer retroarc area.

Younger arc related rocks were emplaced more than 550 kilometers away from the trench in the eastern slope of the Andes, during Late Miocene times (20-4 Ma) from 34°30´to 37°45´S. At the retroarc zone basement blocks cannibalized the foreland basin in Late Miocene times associated with the Malargüe fold and thrust belt to the west, whose main phase of contraction has been constrained in 20-10 Ma.

This indicates a genetic relationship between the arc expansion, uplift of the Andes, sedimentation in the foreland basin, and the breaking of the foreland area. This stage changed to an extensional regime since Latest Miocene-Early Pliocene times. Extensional troughs were developed in the area that previously recorded arc expansion until late Quaternary, controlling the emplacement of crustal melts and poorly differentiated mantle products. Presently this area is associated with crustal attenuation as well as anomalous sublithospheric heating inferred by teleseismic, tomographic and gravimetric analysis.

References

Burns W M (2002) Tectonics of the Southern Andes from stratigraphic thermochronologic and geochemical perspectives. Unpubl. Phd Thesis Cornell University Ithaca NY: 204 pp

Groeber P (1929) Líneas fundamentales de la geología del norte del Neuquén. Dirección General de Minas Geología e Hidrología Publicación 58: 108 pp Buenos Aires.

Ramos V A, Pimentel M, Tunik M (2008) Late Cretaceous synorogenic deposits of the Neuquén Basin (36-39°S): Age constraints from U-Pb dating in detrital zircons. In: Proceedings 7th International Symposium on Andean Geodynamics: 423-426 Nize

Silvestro J, Atencio, M (2008) La cuenca Cenozoica del Río Grande y Palauco: edad, evolución y control estructural Faja plegada de Malargüe (36°S). Revista de la Asociación Geológica Argentina In Press

Zamora Valcarce G, Zapata T, Ramos V.A, Rodriguez Monreal F (2008) Evolución tectónica del frente andino de Neuquén Faja Plegada del Agrio. In: Proceedings 17th Congreso Geológico Argentino Jujuy Argentina Electronic Files

---

Are the North Patagonia islands the key areas to test the Darwin’s glacial hypothesis?

Francois JP

Seminar für Geographie und ihre Didaktik. Universität zu Köln, Deutschland, geofrancois@gmail.com

Since the first observations realized by Charles Darwin during he’s journey aboard the H.M.S. “Beagle”, a noteworthy “glacial footprint” has been recognized in the Southern Andes geography. Huge moraines complexes, with dammed lakes, and broad outwash-plains along the Andes slopes have been recognized and mapped during the last century (Steffen 1909; Quensel 1910; Caldenius 1932; Moreno 1969), and later dated (Mercer 1976; Denton et al. 1999b; Wenzens 1999; McCulloch et al.

2005; Douglass et al. 2006). Botanical expeditions, also developed during the past century, describes in detail the distributions of plant communities and its correlation with the climatic gradients (Schmithüsen 1956; Oberdorfer 1960). Utilizing these geological and botanical results, pollen records from Patagonia became possible to test a classical hypothesis proposed by Darwin. This premise suggests that the growth and spread of an ice cover in the southern Andes during the last ice age forced the migration of plants to non-glacial areas (Darwin 1859; Barlow 1969). Thus, pollen records from Chilean Central Valley show a displacement in the vegetational formations to lower latitudes (and altitudes) during the last ice age, in agree with the Darwin's glacial hypothesis (Heusser 1994; Villagrán 2001). Vegetational refuges have been proposed for the northwest area of the Chiloé Island and the adjacent Continental Costal Cordillera. But, it is possible the presence of others vegetation refuges during the last glaciation? Geomorphologic studies developed in the Chiloé Island conclude that an ice lobe covered the southern half the island during the last glacial maximum (LGM), 29.400-14.450 14C yr BP (Denton et al. 1999a). However, aerial and satellite images show complex drainage networks in the southwestern portion of the island, that contrast with the scoured landscape in the southeastern area, suggesting: a differential erosion process during the postglacial (related to the type of rock), or unglaciated areas of the coast of the South Pacific during the LGM. The dissimilar pattern "dendritic drainage v/s scoured bedrock" is observable too if compares the oceanic islands Guafo and Guamblin with the other islands in the Chonos archipielago. Recent expeditions to these areas (Southern Chiloe and oceanic islands) indicate high endemism values in the flora and fauna, suggesting longs periods of isolation. Pollen records from the Chonos archipelago are ambiguous about the existence of vegetational refuges during the LGM (Haberle & Bennett 2004). However, pollen studies from the Taitao Peninsula (Heusser 2002) suggest that not was totally ice cover during the LGM, in disagreement with reconstructed the models of glacial reconstruction (Hubbard et al. 2005). In conclusion, southwest Chiloe and the Islands Guafo-Guamblin are key areas to develop geomorphological studies in order to define the ice limit during the LGM. As well, pollen studies from these areas would allow evaluate the refuges hypothesis, and the possible existence of sites that cover the last interglacial.

References

Barlow N (1969). Charles Darwin's Diary of the Voyage of H.M.S. "Beagle". New York, Cambridge Univ. Press

Caldenius C (1932) Las glaciaciones cuaternarias en la Patagonia y Tierra del Fuego. Geografiska Annaler 14: 1-164

Darwin CH (1859). The Origin of Species. Oxford, Penguin Books. 477

Denton GH, Heusser CJ, Lowell TV, Moreno PI, Andersen BG, Heusser L, Schlüchter C, Marchant DR (1999a) Interhemispheric linkage of paleoclimate during the last glaciation. Geografiska Annaler 81 A: 107-153

Denton GH, Lowell TV, Heusser CJ, Schlüchter C, Andersen BG, Heusser LE, Moreno PI, Marchant DR (1999b) Geomorphology, stratigraphy, and radiocarbon chronology of Llanquihue drift in the area of the Southern Lake District, Seno de Reloncaví, and Isla Grande de Chiloé, Chile. Geografiska Annaler 81 A(Series A-Physical Geography): 167-229

Douglass DC, Singer BS, Kaplan MR, Mickelson DM, Caffee MW (2006) Cosmogenic nuclide surface exposure dating of boulders on last-glacial and late-glacial moraines, Lago Buenos Aires, Argentina: Interpretive strategies and paleoclimate implications. Quaternary Geochronology 1(1): 43-58

Haberle S, Bennett K (2004) Postglacial formation and dynamics of North Patagonian Rainforest in the Chonos Archipelago, Southern Chile. Quaternary Science Reviews

Heusser CJ (1994) Pattern of glacial-interglacial vegetation in subtropical Chile. Historical Biology 9: 35-45

Heusser CJ (2002) On glaciation of the southern Andes with special reference to the Peninsula de Taitao and adjacent Andean cordillera (46º30'S). Journal of South American Earth Sciences 15: 577-589

Hubbard A, Hein AS, Kaplan MR, Hulton NRJ, Glasser N (2005) A modelling reconstruction of the late glacial maximum ice sheet and its deglaciation in the vicinity of the Northern Patagonia Icefield, South America. Geografiska Annaler 87A(2): 375-391

McCulloch RD, Fogwill CJ, Sugden DE, Bentley MJ, Kubik PW (2005) Chronology of the last glaciation in the central Strait of Magellan and Bahía Inútil, southernmost South America. Geografiska Annaler 87A(2): 289-312

Mercer J (1976) Glacial history of Southern South America. Quaternary Research 6: 125-166

Moreno FP (1969). Viajes a la Patagonia Austral 1876-1877. Buenos Aires

Oberdorfer E (1960) Pflanzensoziologische Studien in Chile - Ein Vergleich mit Europa. Flora et Vegetatio Mundi 2: 1-208

Quensel PD (1910). On the influence of the ice age on the continental watershed of Patagonia Bulletin of the Geological Institution of the University of Upsala. HJ Sjögren. Upsala. 6: 61-92.

Schmithüsen J (1956) Die raumliche Ordnung der chilenischen Vegetation. Boner Geogr. Abh 17: 3-86

Steffen H (1909). VI. Memoria sobre la espedicion esploradora del Rio Cisnes (1) Viajes de esploracion i estudio en la Patagonia Occidental 1892-1902. Santiago, Chile. Anales de la Universidad de Chile.

Villagrán C (2001) Un modelo de la historia de la vegetación de la Cordillera de la Costa de Chile central-sur: la hipótesis glacial de Darwin. Revista Chilena de Historia Natural 74: 793-803

Wenzens G (1999) Fluctuations of outlet and valley glaciers in the Southern Andes (Argentina) during the past 13,000 years. Quaternary Research 51: 238-247.

Identificación de la susceptibilidad a inundación en las formas exocarsticas del noreste de península de Yucatán, México.

Frausto-Martínez O 1, Ihl T 2, Giese S 3

1 Universidad de Quintana Roo / Universidad Bauhaus Weimar, ofrausto@uqroo.mx
2 Universidad de Quintana Roo, thomas@uqroo.mx
3 TLWG, Weimar, S.Giese@TLUGJena.Thueringen.de

La identificación de áreas susceptibles a inundación en la península de Yucatán parte del estudio del relive y de la geografía del riesgo, cuyo fundamento es el análisis geomorfológico a escala media - 1:50 000- (Frausto, 2002; Frausto et al. 2006). En este tipo de análisis hace referencia a la prevención de los desastres naturales con base en la diferenciación territorial, en la morfología del relieve (altura, pendiente y profundidad), vinculada a los procesos de inundación (Frausto, O. 2003; Goldacker, et al. 2005; Ihl, et al. 2007, y Frausto & Ihl 2008). En la península de Yucatán, los efectos negativos que ocasionaron los huracanes en la región -Isidoro, Wilma y Dean-, pone de manifiesto la recurrencia de las inundaciones por eventos extremos. En la actualidad, no existe cartografía detallada del relieve y de las áreas susceptibles a inundaciones que permita la planificación para la prevención de desastres en la región noreste de la península. Asi, con fundamento en las técnicas de reconocimiento de las formas exocársticas, diferenciación de los procesos de inundación y la identificación de localidades en riesgo se presenta el estudio de la susceptibilidad a inundaciones de las formas exocársticas del noreste de la península de Yucatán.

El objetivo central es la identificación de los procesos de inundación en las formas exocarsticas con el fin de reconocer la susceptibilidad del noreste de la península de Yucatán a riesgo por inundaciones. Para el logro del mismo, fue necesario reconocer las formas exocársticas (relieves topográficamente superficiales y con reflejo directo) y diferenciar la susceptibilidad a inundaciones en este tipo de relieves, lo cual es resultado de la interpretación directa de fotografías áreas escala 1:20000 del INEGI y de imágenes de satélite Landsat, de la interpretación y manejo de los datos vectoriales de los mapas topográficos a escala 1:50000 de INEGI, así como de recorridos de campo y registros de las formas cársticas reportadas en la bibliografía especializada. Se construyó una base de datos topográfica y temática que hace referencia a la altitud, la pendiente del terreno y cuerpos de agua y se relacionan los procesos de inundación (permanentes, ordinarios y extraordinarios), finalmente, se realizó un análisis espacial de la ubicación de las localidades sujetas a inundaciones, todos estos elementos constituyen el sistema de información geográfica de la susceptibilidad a la inundación del noreste de la península de Yucatán, con una resolución a 1:50000.

Los resultados principales son:

La cartografía de formas exocársticas es el primero en su tipo en la península de Yucatán, en el cual se hace referencia a tres tipos de estructuras: dolinas, úvalas y poljes, diferenciadas según su profundidad (de 0 m y hasta 30 mts) y su ubicación

topográfica (hasta 40 metros de altitud), asimismo, se hace referencia al patrón de inundación (ordinario, permanente o extraordinario). El mapa de formas exocársticas se enriquece con el apartado de densidad de formas por kilómetro.

La colección del Sistema de Información Geográfica lo constituyen 28 cartas a escala 1:50000 y se hace referencia específica a estas formas del relieve a una escala media, por lo que enriquecerá el compendio de cartas temáticas a escala 1:250000 que se están desarrollando sobre los diferentes aspectos que constituyen el conocimiento y manejo de los recursos naturales, en especial el manejo del recurso agua.

El mapa está disponible en un formato simple de consulta a través del SIG, lo que le imprime un carácter dinámico y de actualización continua, favoreciendo su consulta y uso. Finalmente,

Se desarrolla el modelo de susceptibilidad a inundación en las formas exocársticas del noreste de la península de Yucatán, resaltando aquellas de carácter permanente, ordinario y extraordinario, y se vincula la ubicación de las localidades con el fin de conocer aquellas que se encuentran en peligro y riesgo.

References

Frausto, O. (2002). Análisis geomorfológico aplicado a los procesos de ladera en la sierra de Guadalupe, México. Tesis de maestria en geografía. Posgrado en Geografía, FFyL-UNAM. 189 p.

Frausto, Ihl, Goldacker, Chale, Giese, Wurl, Careaga y Bacab (2006). Areas susceptiblea de riesgo en localidades de pobreza extrema en el sur de Yucatán. Universidad de Quintana Roo. Teoría y Praxis 2, 87-103.

Frausto, O. (2003). Identificación de áreas susceptibles a riesgo en localidades de pobreza extrema del sur de Yucatán.FOMIX-CONACYT-YUCATAN. Memoria técnica, Mérida.

Goldacker, Frausto, Rojas, Giese (2005): Identification of areas at risk of flooding in the south of the Yucatan peninsula, México. – in: Kauffer- M. F. (Ed.). El agua en la frontera México- Guatemala – Belice: Col. De la Frontera Sur-UNICHIAPAS. 483-495.

Ihl, Frausto, Rojas, Giese, Goldacker, Bautista & Bocco (2007): Identification of geodisasters in the state of Yucatán, México. N. Jb. Geol. Paläont., Abh., 246:299-311; Stuttgart.

Frausto, O. & Ihl, T. (2008): Mapa de formas exocársticas del norte de Quintana Roo a escala 1:50000. En: Gutiérrez, M. & Adrián Cervantes, Estudio geohidrológico del norte de Quintana Roo, México. FOMIX CONACYT-QROO, UQ-ROO. 45 -58.

Structure and tectonics of the inner retro-arc between 38º30' and 40ºS

García Morabito E , Ramos VA

Laboratorio de Tectónica Andina. Universidad de Buenos Aires, ezegm@gl.fcen.uba.ar

Several fold-and-thrust-belts with distinctive deformation styles have been recognized between 37º and 42ºS, some of the regions in which these belts occur, received considerable attention along the last decades, like the Andean eastern flank between 36º and 38º30'S (Guañacos, Chos Malal and Agrio fold-and-thrust belts), and the North Patagonian Andes between 41º-42ºS (North Patagonian fold-and thrust belt). In spite of that, there are some segments along the eastern flank of the Andes where timing, onset and style of the deformation remains poorly constrained. This is the case of the Andes between 38º30' and 40ºS, were the structure and tectonics of the inner retro-arc area is poorly understood because of the scarcity of structural studies, with the exception of the regional surveys made by Lambert (1948) and Turner (1973, 1976).

The inner retro-arc area between these latitudes can be divided into an internal and external domain based on its distinctive structural evolution. The boundary between them coincides with the valley of the Alumine river, which separates two sectors of the fold-and-thrust-belt with opposite vergence and different structural styles. The internal domain is characterized by north-south east-verging trending faults which mainly affect the igneous rocks of the North Patagonian Batholith. Structures developed in the external domain during the Andean cycle are associated with a fold-and-thrust-belt with a clear west-verging geometry, which was controlled geometrically by pre-existing normal faults of the Mesozoic rift phase. These two systems with opposite vergence define a thick-skinned triangular zone along the Bio Bio and Alumine valleys.

The Copahue – Pino Hachado Block (CPHB) and its prolongation to the south in the Cordilleras de Catan Lil and Chachil represents a key feature within the internal domain to understand the structure and tectonic of the inner retro-arc area between 38°15' and 40ºS. It extends for about 180 km from north to south reaching higher altitude values than the Main Cordillera and separated by more than 100 km from the volcanic arc. Associated with its western flank we recognize a narrow belt of Tertiary depocenters which concentrates variable thicknesses of volcaniclastic and clastic sequences assigned to the Mitrauquen and Chimehuin Formations. Along-strike differences in styles, magnitude and distribution of the deformation allowed us to define three segments along the external domain, each of one is associated with one of these depocenters.

Based on new structural data and tectonostratigraphic evidences, we establish that the last Andean contraction phase that give rise to the final uplift of the Copahue – Pino Hachado Block, and to the Cordilleras de Catan Lil and Chachil can be constrained to the Late Miocene. The volcanic and sedimentary sequences that con-

stitutes the infill of these depocenters represents synorogenic deposits associated with the final uplift of these basament blocks. A southward younging of the deformation can be recognized as well. Hence, this NW-trending structural high has been reshaped during the Late Miocene after a first phase of compressional deformation between the Late Cretaceous and the Eocene constrained by fission track ages along the CPHB (Thomson et al., 2008) and the Lonquimay Massif (Gräfe et al., 2002), and related to an eastward expansion of Late Cretaceous to Eocene arc related products, which leaded Ramos and Folguera (2007) to propose a shallowing of the subducted plate for the segment located inmediatly north of the study area for that period.

References

Gräfe, K, Glodny, J, Seifert, W, Rosenau, M, and Echtler, H (2002) Apatite fission track thermochronology of granitoids at the south Chilean active continental margin (37ºS – 42ºS): Implications for denudation, tectonics and mass transfer since the Cretaceous, in 5th International Symposium of Andean Geodynamics [extended abstracts]: IRD (Institut de Reserche pour le Développement) Toulusse, France

Lambert, L R (1948) Geología de la zona de las cabeceras del río Catan Lil, Territorio del Neuquén. Revista de la Asociación Geológica Argentina, 3 (4): 245-257

Ramos, V A and Folguera, A (2006) Tectonic evolution of the Andes of Neuquén; constrains derived from the magmatic arc and foreland deformation. In: Veiga, G D, Spalletti, L, Howell, J A, Schwarz, E (Eds), The Neuquen Basin: A case study in Sequence Stratigraphy and Basin Dynamics. GS, London, Special Publications, vol 252: 15-35

Thomson, S N, Brandon, M T, Reiners, P W, Vásquez, C & Tomkin, J H (2008) Thermochronologic evidence for a poleward transition from destructive to constructive glacial control on mountain building: an example from the Patagonian Andes. In: Garver, J I and Montario, M J (eds) Proceedings from the 11th International Conference on Thermochronometry, Anchorage, Alaska, Sept 2008: 232-235

Turner, J C, (1973) Descripción de la Hoja 37 a-b, Junín de los Andes, provincia del Neuquén. Servicio Nacional Minero Geológico, Boletín 138: 1-86

Turner, J C (1976) Descripción de la Hoja 36 a, Aluminé, provincia del Neuquén. Servicio Geológico Nacional, Boletín 145: 1-80

Processing of 4C-2D OBC reflection seismic data from the southern Gulf of Mexico (Oil Field Cantarell)

Garza-Rocha D 1, Rabbel W 2, González-Roque AA 1, Vásquez-García, M 3

1 Facultad de Ciencias de la Tierra, U.A.N.L., México, dagarza@fct.uanl.mx
2 Institut für Geowissenschaften, (Abt. Geophysik), University of Kiel
3 Gerencia de Geofísica, PEMEX, Villahermosa, Tabasco, México

In the present work we show 4C OBC seismic reflection data from the Oil Field Cantarell. These data were measured in year 2000, in southern Golf of Mexico by the mexican Oil Company PEMEX. This was the first time, that PEMEX uses this technologie in Mexico. The area of the measurements, builds one of the big Oil fields in Mexico, the so called Cantarell Oil Field. The data were recorded with two lines with 201 geophone and six linien with 182 and 319 sources. The geophone and hydrophone were located in an Ocean Bottom Cable in a depth of about 25 meter in seafloor. The sources were located in a depth of about 5 meter under watersurface. The main goal of our work was to obtain the stacking of the P-SV reflected converted waves. To process these data, we must obtain the separation of four components, the hydrophon component, the vertical component (P-P reflection), the radial component (P-SV reflection) and the transversal component (P-SH reflection). With the aid of the summation, of the hydrophon component and the vertical component we obtain the total wave field of the P-wave. After the summation, we process these data to obtain the values of the velocity of the P-wave. If we know the distribution of the velocities of the P-wave, we can now carry out the process of the P-SV reflected converted waves, this was the main objetive of our work. Differents ways to carry out the stacking of P-SV reflected converted waves were applied. We have two principal problems, if we want carry out the stacking of P-SV reflection data: a) the sorting of common converting points (selection of the CCP´s) and b) the correction of the normal moveout of the groups of CCP´s. As result in our work, we can show the development of an efficient way to carry out the stacking of P-SV reflected converted waves. The parameter the we can get with this method are for example the velocity of the shear wave, the ratio of the velocity shear wave to the velocity of the compressional wave and the poisson´s number. These parameter are obtained under the use of a coherence analysis. Finally, after the processing, we get some seismic sections from the field data (stacking seismic section, coherency seismic section, better fit parameter for stacking, migration of the stacked reflection seismic data).

Eocene opening of Drake Passage: Geological and Geophysical evidence from Tierra del Fuego

Ghiglione MC 1, 2, Yagupsky DL 3, 2, Ghidella M 4, Ramos VA 1

1 Laboratorio de Tectónica Andina, Univ. de Buenos Aires, Argentina, matias@gl.fcen.uba.ar
2 Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET),
3 Laboratorio de Modelado Geológico (LaMoGe), Univ. de Buenos Aires, Argentina
4 Instituto Antártico Argentino, Cerrito 1248, Buenos Aires, Argentina

Due to the tremendous impact of the present global warming, it has became essential to understand the causes and processes involved in past climate changes. One of the most prominent events in Earth's climatic evolution was the transition from the global warmth of the Eocene "greenhouse" to the Oligocene “icehouse” glacial conditions, but, why did it happen?

It is widely believed that the separation of South America from Antarctica and the subsequent formation of Drake Passage have influenced Cenozoic global cooling because these events enabled the development of the Antarctic Circumpolar Current. This wind-driven current is speculated to have reduced heat transport to Antarctica, triggering the Oligocene global cooling. It has been proposed alternatively that opening of Drake Passage influenced circulation-induced productivity increase that may have sequestered atmospheric CO2, contributing to global cooling and Antarctic glaciation. While the former theory is based on the presumption that the marine connection was coeval with initiation of the Antarctic glaciation at the Eocene-Oligocene boundary, the latter requires an earlier (middle Eocene) ocean water exchange. Unfortunately, age estimates for the onset of a seaway through Drake Passage range from middle Eocene to Miocene, complicating interpretations of the relation between ocean circulation and global cooling.

Studying the southeast tip of Tierra del Fuego, a region that was once attached to the Antarctic Peninsula, we discovered evidences for the opening of widespread early Eocene extensional depocenters. Here we present evidence for the presence of a Paleocene – Eocene extensional basin (i.e. lateral rift) located parallel to the actual continental-oceanic crust boundary in Tierra del Fuego. An accurately-dated post-rift unconformity indicates that extensional faulting ended in this area at ~50 Ma, in concurrence with a previously reported eightfold increase in South America – Antarctica separation rate, and the onset of oceanic basins in the incipient Drake Passage. The coincidence of these facts indicates progressive strain concentration on the zone of future crustal separation (i.e. Drake Passage) after abandonment of lateral rifts. The presented data bolster previously proposed interpretations of an early (Eocene) marine gateway by confirming the prediction of a continental extensional regime in the region during the period prior to the opening of the small Protector and Dove basins near 42 Ma. This succession of events is in accordance with recent theories supporting that the opening of a seaway through Drake Passage was early enough to contribute to global cooling through lowering levels of atmospheric CO2.

Magmatic evolution of the two caldera-forming Tephras of the Apoyo Caldera / Nicaragua

Gilbert D, Freundt A, Kutterolf S

SFB 574 at IFM-GEOMAR, Kiel, Germany, dgilbert@ifm-geomar.de

The Apoyo Caldera in Nicaragua, part of the Central American Volcanic Arc, produced two Plinian eruptions separated by less than 10^3 years time break emplacing the Lower Apoyo Tephra (LAT) and Upper Apoyo Tephra (UAT). The evolution of both erupted dacitic magmas was controlled by fractional crystallization of variable Plag-Cpx-Opx-Ol-Fe-Ti-oxide assemblages in connected reservoirs at 24-27 km and 9-13 km depth. Fractionation was modified by mingling with two types of less-evolved magmas. Type (1) was typical LIL-rich arc magmas ranging from less evolved to more highly differentiated compositions. Type (2) are cumulate xenoliths, xenocrysts (high-Mg olivines) and mafic bands in mingled pumices that are compositionally related to the low-Ti magmas of the Granada and Nejapa-Miraflores lineaments. These lineaments are N-S-trending fault zones straddled by numerous basaltic cinder cones and tuff-rings that divide and offset the Nicaraguan volcanic arc.

Resorption and growth patterns of zoned phenocryst show that mixing events of variable extent occurred repeatedly. The most recent mixing events are recorded as three levels of inflection in the vertical compositional zonation of the tephras occurring (a) within LAT, (b) at the LAT-UAT transition, and (c) in the uppermost UAT.

(a) Abundant mingled pumices, xenocrysts and cumulate xenoliths compositionally similar to Granada Lineament low-Ti magmas, and absence of diffusive re-homogenization, suggest admixing of the mafic components to the dacitic reservoir a short time before the LAT eruption. Such mixing may actually have triggered the eruption.

(b) Compared to LAT, the UAT composition is more homogeneous, suggesting re-homogenization of the mixed LAT reservoir during the time break until the UAT eruption. However, compositions of lower UAT-1 and middle UAT-2 have lower silica contents than evolved LAT dacite but higher contents of incompatible traces (e.g., REE). UAT thus is not simply the product of mixing the components already found in LAT but requires additional fractional crystallization during re-homogenization.

(c) The less evolved bulk composition and much wider scatter in glass compositions of the upper unit UAT-3 coincide with a coarsening in tephra grain size indicating the highest mass discharge rates of the eruption. At such high discharge rates, deeper, less evolved horizons of the magma chamber were tapped leading to intense syneruptive magma mingling in the conduit.

Long-term landscape evolution at the Western South Atlantic passive continental margin, Brazil

Glasmacher UA 1, Hackspacher P 2, Förster A 3, Franco AOB 2, Doranti C 2, Godoy D 2, Karl MP 1

1 Institute of Earth Sciences, Heidelberg University, INF 234, 69120, Heidelberg, Germany, ulrich.a.glasmacher@urz-uni-heidelberg.de

2 Institute for Geosciences, State University of São Paulo 13506-900, Rio Claro, SP, Brazil

3 GFZ Potsdam, Geothermics, Germany

In SE- and S-Brazil, the Precambrian metamorphic basement is overlain by a thick sequence (~5500 m) of Devonian to Jurassic siliciclastic and carbonate rocks that are folded into large antiformal (Ponta Grossa Arch) and synformal structures (Torres syncline) of unknown formation age The tilted, uplifted, and partly eroded Palaeozoic to Pre-Cretaceous Mesozoic strata indicates a Pre-rift topography. About 1500 m of Early Cretaceous Paraná flood basalts (133 (1) Ma) fill and overlay the ~140 Ma old topography. Furthermore, in the late Early Cretaceous (~133 Ma), the Precambrian basement, and the Devonian to Jurassic sedimentary rocks were truncated by two large NW-SE trending magmatic dike swarms. The next clear geological record at the onshore part of the passive continental margin is provided by localized larger volume intrusion of Late Cretaceous (~90 Ma) alkaline magmas. The Late Cretaceous (~90 Ma) alkaline volcanics, subvolcanics and intrusions occur partly in two NW-SE trending belts and are partly unrelated to larger lineaments. At about the same time, the deposition of Late Cretaceous siliciclastic rocks (Bauru Group) fill the second topography, the Paraná flood basalt surface. The thickness of the Late Cretaceous siliciclastic sequence increases from the continental margin into the Paraná basin. The sedimentary detritus is partly derived form the Early Cretaceous flood basalts. Recently, the Early Cretaceous flood basalts and the Late Cretaceous sedimentary rocks are tilted with a dip to the NW in the State Sao Paulo. In addition, local horst structures of Paleogene age modify the general structural trend. Close to the recent coast erosion exhumed the Precambrian basement prior to the evolution of the Eocene (~40 Ma) to Miocene (~20 Ma) NE-SW trending (~2000 km) onshore/offshore graben system of SE Brazil. The graben system was filled with thick terrigenous sediments (Pariqueracu basin). The evolution of the large graben system might be related to processes at the western active continental margin of South America. In the Paraná State, pre-Eocene-Pre-Miocene topography is filled with Paleogene-Neogene sediments (e.g. Resende For. 45 Ma; Ankaramite For. 55 Ma). At the same time, in the offshore basins large volumes of submarine volcanic rocks were deposited. Inversion of the rift basin took place in post-early Miocene time. The coastal lowlands are strongly influenced by the last sea-level rise following the last ice age (~20 ka). Pleistocene or older valleys are filled with larger amount of younger sediments. We will present thermochronological data to provide further evidence for the long-term landscape evolution of the passive continental margin

(Hackspacher et al. 2004, Doranti et al. 2008, Franco et al. 2008).

References

Hackspacher PC, Ribeiro LFB, Ribeiro MCS, Fetter AH, Hadler Neto JC, Tello CAS, Dantas EL (2004) Consolidation and Break-up of the South American Platform in Southeastern Brazil: Tectonothermal and Denudation Histories. Gondwana Research 7, 91 - 101.

Franco AOB, Glasmacher UA, Hackspacher PC, Hadler Neto JC (2008) Low-temperature post-rift evolution of the western South-Atlantic passive continental margin, Brazil -apatite fission-track thermochronology. In: European Geosciences Union (EGU) – Gen. Ass., 2008, Vienna, Proc, CD-Rom.

Doranti C, Glasmacher UA, Hackspacher PC, Hadler Neto JC (2008) Temperature, exhumation, and landscape evolution of the Pocos de Caldas alkaline massive region, SE Brazil. In: European Geosciences Union (EGU) – Gen. Ass., 2008, Vienna, Proc, CD-Rom.

Improvement of a local geoid model in Tierra del Fuego

Gomez ME 1, Richter A 2, Mendoza L 1

1 Fac.de Cs. Astronómicas y Geofísicas-UNLP, megomez@fcaglp.unlp.edu.ar
2 Institut für Planetare Geodäsie-TU Dresden.

Since the establishment of the national GPS/levelling network in the area of Tierra del Fuego, several attempts to compute a geometric geoid model have been realized. Also the Fagnano lake surface has been measured in order to use it as an indicator for a geopotential surface. A regional geoid model for the Argentine part of Tierra del Fuego was presented by Del Cogliano et al. 2007.

In the last year a new leveling line was measured in the East West direction and the GPS coordinates of all the GPS/levelling points were referred to a new reference frame, TDF08 (Mendoza, 2008) close to ITRF. Those efforts allowed us to confirm the geoid shape and the agreement with global geopotential models, including EGM2008. At the moment, the activities are focused on the investigation of a combined gravimetric/geodetic geoid model.

References

Del Cogliano D., Dietrich R., Richter A., Perdomo R., Hormaechea J. L., Liebsch G, Fritsche M. (2007) Regional geoid determination in Tierra del Fuego including GPS levelling. Geologica Acta, Vol. 5, Nº 4.

Reflection Seismic Imaging of the Chilean Subduction Zone around the 1960 Valdivia Earthquake Hypocenter

Groß K , Buske S , Shapiro SA , Wigger P

Department of Geophysics, Free University Berlin, Germany, kolja@geophysik.fu-berlin.de

Introduction: With a quarter of the worldwide seismic energy in the last century having been released in the Chilean region alone (Scholz 2002), the Andean subduction zone is a natural laboratory for our seismogenic zone studies. The overarching purpose of project TIPTEQ (from The Incoming Plate to mega-Thrust EarthQuake processes), which comprises 13 subprojects, is to investigate processes active at all scales in the seismogenic coupling zone in south central Chile and northern Patagonia , which hosted the rupture plane of the 1960 Valdivia earthquake (Mw =9.5) (Cifuentes 1989; Barrientos & Ward 1990).

In this paper we present a structural image and an interpretation of the reflection seismic data set across the Chilean subduction zone. Reflection seismic data was acquired along an approx. 100 km long profile running from west to east across the Chilean subduction zone at 38.2° S. For details on the experiment design and acquisition parameters see Groß et al. (2008).

Data processing: The SPOC wide-angle refraction experiment provided us with a P-wave velocity model (Krawczyk & the SPOC Team 2003) along the same latitude. This velocity information was used to produce a prestack depth migrated section of the vertical component of the Near Vertical Reflection (NVR) data set. Kirchhoff pre-stack depth migration (KPSDM) was performed in a 3-D volume using the true source and receiver coordinates, thereby taking into account the actual crooked line geometry and the topography along the profile using the method of Buske (1999). The single shot gathers were migrated separately using the true phase information. Then trace envelopes of all migrated single shots were calculated and stacked to form a 3-D image. An analysis of the 3-D migration volume showed almost no structural dip perpendicular to the survey line. That allowed us to further increase the signal-to-noise ratio up to a factor of 2 by summing of the W-E oriented depth slices.

The migration of all three components considering P- and S-wave traveltimes (PP, SS), as well as converted waves (PS, SP) shows S-wave energy from the plate interface down to a depth of approx. 35 km. There is almost no converted energy observed. We characterized the subduction zone further using two innovative imaging techniques based on KPSDM: Reflection Image Spectroscopy (RIS) and Fresnel Volume Migration (FVM).

Results and discussion: The seismic sections clearly show the subducted oceanic Nazca plate below the segmented forearc and a highly reflective overriding South American

plate. We associate high reflectivity at the plate interface with the existence of a subduction channel with a varying thickness of 2-5 km down to a depth of at least 38 km. It

might continue towards depth. The continental Moho is not clearly imaged. We observe reflectivity east of the 1960 hypocenter that shows horizontal structures at various depths, which give rise to different eastward continuations of the continental Moho. The position and extent of the continental mantle wedge changes accordingly. Major forearc features such as the crustal Lanalhue fault zone and a strong west-dipping reflector perpendicular to the plate interface, can be observed.
We compared the pattern of reflectivity with other, independent geophysical results obtained within project TIPTEQ. The comparison with the P-wave velocity model from local earthquake tomography (Haberland et al. 2008) shows good correlation between high velocities and high reflectivity in the continental crust (and vice versa) and the comparison to the distribution of electrical resistivity (Brasse et al. 2008) shows a correlation of low resistivity and high reflectivity (and vice versa).

The area around the 1960 Valdivia earthquake hypocenter is characterized by high electrical resistivity and low reflectivity. Migration of lowpass filtered seismic data (RIS), however, images the plate interface as a continuous linear feature, that shows no reduced reflectivity around the hypocenter. For a more detailed discussion of the seismic section see Groß et al. (2008).

Acknowledgements: This work was part of the R&D-Program GEOTECHNOLOGIEN funded by the German Ministry of Education and Research (BMBF) (Grant 03G0594) and the German Research Foundation (DFG). The project benefited from grants of the Freie Universität Berlin and the GFZ Potsdam; seismic stations were provided by the Geophysical Instrument Pool Potsdam and the Freie Universität Berlin. We thank all participants in the field and the Chilean inhabitants for having made this survey possible.

References

Barrientos S, Ward S (1990) The 1960 Chile earthquake: inversion for slip distribution from surface deformation. Geophys. J. Int. 103 589-598

Brasse H, Kapinos G, Li Y, Mütschard L, Soyer W, Eydam D (2008) Structural electrical anisotropy in the crust at the South-Central Chilean continental margin as nferred from geomagnetic transfer functions. PEPI submitted

Buske S (1999) Three-dimensional pre-stack Kirchhoff migration of deep seismic eflection data. Geophys. J. Int. 137 243-260

Cifuentes I (1989) The 1960 Chilean earthquake. J. geophys. Res. 94(B1) 665-680

Groß K, Micksch U, TIPTEQ Research Group, Seismics Team (2008) The reflection seismic survey of project TIPTEQ -the inventory of the Chilean subduction zone at 38.2° S. Geophysl J International 172 (2) 565-571 doi:10.1111/j.1365-246X.2007.03680.x

Haberland C, Rietbrock A, Lange D, Bataille K, Dahm T (2008) Structure of the seismogenic zone of the South-Central Chilean margin revealed by local earthquake travel time tomography. J. Geophys. Res., doi:10.1029/2008JB005802, in press (accepted 3 November 2008)

Krawczyk C, the SPOC Team (2003) Amphibious seismic survey images plate interface at 1960 Chile earthquake. EOS Trans. Am. geophys. Union 84(32) 301 304-305

Krawczyk C, Mechie J, Lüth S, Tašárová Z, Wigger P, Stiller M, Brasse H, Echtler H P, Araneda M, Bataille K (2006) Geophysical Signatures and Active Tectonics at the South-Central Chilean Margin. In The Andes-Active Subduction Orogeny. Frontiers in Earth Sciences Vol. 1 pp. 171-192 eds Oncken O, Chong G, Franz G, Giese P, Götze H, Ramos V, Strecker M, Wigger P Springer Verlag Berlin

Melnick D, Echtler H (2006) Morphotectonic and geologic digital map compilations of the south-central Andes (36-43° S). In The Andes-Active Subduction Orogeny. Frontiers in Earth Sciences Vol. 1 pp. 565-568 eds Oncken O, Chong G, Franz G, Giese P, Götze H, Ramos V, Strecker M, Wigger P Springer Verlag Berlin

Reichert C, Schreckenberger B (2002) Cruise report SO-161 leg 2 & 3, SPOC (Subduction Processes Off Chile). Tech. rep. BGR Hannover 142 pp

Scholz C (2002) The Mechanics of Earthquakes and Faulting. Cambridge University Press Cambridge UK 471 pp.

Moa Bay, eastern Cuba: Geoenvironmental characteristics and problems of a modern tropical lagoon – first results

Gursky HJ 1, Orozco G 2, Cervantes Y 2, Pierra A 2, Schwarzer A 1

1 Inst. f. Geologie und Paläontologie, TU Clausthal, Germany, gursky@geologie.tu-clausthal.de
2 Departamento de Geología, Instituto Superior Minero-Metalúrgico, Moa, Cuba

The Republic of Cuba is an archipelago consisting of a large main island and several hundred surrounding minor islands and keys (cayos). Due to its position between the tropic of Cancer and 20° N latitude, most of the minor islands are coral reefs generally separated from the main land by typical tropical lagoons. One of Cuba's easternmost lagoons is Moa Bay at the northeast coast in the province of Holguín (Oriente region), juxtaposed to the Bahama islands.

The lagoon is approximately up to 5 km long, 3 km wide (ca. 10 km²) and 10 m deep. It has a wide inlet in the east, and water currents are driven westward by the prevailing NE trade winds. Tidal range is only some decimetres, but summertime hurricanes may be impacting. The southern coast line of Moa Bay is characterized by basement rock outcrops of Cretaceous serpentinite with a thick laterite cover; cliffs and gullies indicate active erosion. Here, a small harbour, a fishery marina and some

homes are the only man-made installations along the entire inner bay shoreline. In the hinterland, Moa City with its 40,000 inhabitants is spread over approximately 5 km^2. The east and west coasts of Moa Bay are covered by dense mangrove forests thriving in the warm humid climate. The bay is separated from the open Atlantic Ocean by Cayo Moa, 4 km long and 0.5 km wide, the easternmost member of an island chain topping the coral-reef line that fringes nearly the entire Cuban NE coast. The cayo is abandoned and covered by semi-humid vegetation at its windward Atlantic-facing side and mostly mangroves along its bay-facing side with adjacent sea-grass meadows. The island has a Neogene coral-rock core and an active Caribbean-type coral-reef north front.

Except of some terrigenous clastic sedimentation at its rocky southern shore, most of the bay's modern sediments are biogenic and calcareous. Relatively coarse-grained bioclastic material is deposited at the wave and storm-attacked shores, partly as lag sediments, whereas fine-grained carbonate sands and oozes (cienos) are present in low-energy leeward areas and the deep parts of the bay.

Major human environmental impacts in Moa Bay result from mud deposition along the south coast and open-water ooze mining with a floating dredger in the centre of the bay. Both are activities due to extensive open-pit laterite mining for nickel in the surroundings of Moa City, started in the 60s and intensified since the 90s. The mud is supplied to the bay mostly by the Moa River that erodes laterite and its beneficiation residues and flows into the bay east of the city. The mined carbonate ooze is consumed during nickel beneficiation.

Extreme water turbidity and mud deposition are obvious primary effects of forced mud supply to the southern bay, where the original sedimentation patterns have been widely overwhelmed. The possible effects of the continuous ooze dredging on the sedimentary dynamics of Moa Bay and its shorelines have not yet been investigated. E. g. since some years accelerated erosion is observed at the eastern end of Cayo Moa, where hurricanes are most effective, too. On the other hand, enhanced ooze deposition and seafloor shallowing are visible off the western end of Cayo Moa resulting in mangrove extension. These features indicate longshore drift to the west, parallel to the dominating wind and ocean-current directions. The proportional effects of the human influences are under debate; possible further consequences for the coastal and inner development of Moa Bay are unknown.

In a joint project, ISMM and TUC are studying the marine geology, sedimentology and environmental evolution of Moa Bay by means of remote sensing, ground data and sediment analyses (grain parameters, mineralogy and geochemistry). Essential first results on geomorphologic development, physical character of modern sediments, as well as their mineralogy and environmental geochemistry are presented in our poster; most future investigations will be included in the Ph. D. thesis of Y. Cervantes (in progress).

Luingo (Pucarilla - Cerro Tipillas Volcanic Complex), the oldest caldera in the SE portion of the Central Andes?

Guzmán S 1, Petrinovic I 1, Seggiaro R 2

1 CONICET-IBIGEO, Museo de Ciencias Naturales, Universidad Nacional de Salta, sguzman@unsa.edu.ar
2 Universidad Nacional de Salta

The area with profuse volcanism in the Central Andes between 28 - 16 ºS is known as the Central Volcanic Zone (CVZ: Thorpe et al. 1984). It is characterised by the presence of abundant ignimbrites and lavas that were generated mainly during the Miocene to Recent (e.g. Baker and Francis 1978). In the South CVZ (25 - 27ºS) ignimbrites have scarce detailed studies, and few recognised emission centres. Between 67º - 69ºW they are characterised by small to medium volume (< 10 km3), crystal - poor ignimbrites of felsic composition (e.g. Schunrr et al. 2007). The only exception seems to be the high - volume Cerro Galán System (e.g. Sparks et al. 1985) which is dacitic and crystal-rich.

In the south-eastern portion of CVZ we recognise vast pyroclastic deposits and minor lava flows unrelated with known emission centre which motivated this study. All these deposits are grouped in what we name the Pucarilla - Cerro Tipillas Volcanic Complex (PCTVC). The aim of this contribution is to present the identified emission centre, the field characteristics of the deposits and their volume.

Limited information is available from this complex; the most detailed work was made by González et al. (1999) who described some field characteristics of what they named Cerro Tipillas Volcanic Complex, but no detailed petrological or volcanological studies were carried out. Ages for isolated ignimbrites are 12.11 ± 0.11 Ma (Marrett et al. 1994) for the Pucarilla Ignimbrite, and 15.83 ± 0.44 Ma to 14.75 ± 0.4 Ma for a hornblendic welded tuff (Sparks et al. 1985). Both ignimbrites were correlated between each other (González et al. 1999, Hongn and Seggiaro 2001).

Field relationships indicate that PCTVC units unconformably cover Middle Miocene (e.g. Grier and Dallmeyer 1990) fluvial sediments and medium to high grade metamorphites and granitoids from the local Neoproterozoic - Paleozoic basement.

A detailed mapping and the construction of an isopaque map led way to infer the approximate position of the emission centre of most of the volcanic units. Moreover, the high outcropping volume (> 50 km3 DRE) of pyroclastic deposits points to a caldera as the source. Finally the recognition of caldera rims and intracaldera facies reinforced the previous hypothesis.

Caldera rims are constrained by the presence of a collapse breccia intercalated in highly welded intracaldera tuffs (eastern rim) and by the presence of an arcuate fault in which intensely silicified hydrothermal breccias are hosted (western rim). By this approach, it is defined an E-W to WSW-ENE elongated caldera of 19 km x 13 km.

Pyroclastic deposits from this caldera are characterised by the presence of medium to high grade ignimbrites. They are crystal-rich (up to 48%) massive lapilli tuffs

with intense degree of welding and profuse devitrification. Pumices content varies between 10 - 40% and they have low lithic contents (< 3%). The most developed of all volcanic units from this complex is the Pucarilla Ignimbrite (Hongn and Seggiaro, 2001) that has a date of 12.11 ± 0.11 Ma (Marrett et al. 1994). It reaches distances of 35 km from de source preserving the intense welding degree. Other major unit is the Alto de Las Lagunas ignimbrite, which was dated by Sparks et al. (1985) in 15 Ma and reanalysed by Guzmán and Petrinovic (submitted) in 13.5 Ma. Both ignimbrites are interpreted as the outflow facies.

The intracaldera facies are named Luingo I and Luingo II ignimbrites (crystal-rich massive lapilli tuffs with development of columnar jointing and high welding degree) and are separated by a collapse breccia (Luingo Breccia). As a characteristic, all the intracaldera facies are affected by propylitic alteration.

In the SE margin of the caldera some lava flows were identified, they are considered to represent the posthumous event related to the caldera, and they probably belong to eroded lava domes.

The caldera is interpreted as an overpressure collapse caldera, with no evident resurgent events (Guzmán and Petrinovic, submitted). The intense degree of welding of all the pyroclastic deposits indicates high pre-eruptive temperatures (Sparks and Wilson 1976), high capability of preservation of heat inside the pyroclastic flow and thus high discharge rate and low gas content. The eruptive columns did not reach great height and collapsed almost immediately. The estimated minimum volume of deposits related to the caldera (intracaldera plus outflow facies) is 135 km3 DRE (Guzmán and Petrinovic submitted).

The Luingo Caldera becomes the most eastern of all recognised emission centres related to the formation of high volume deposits in the South CVZ outlining to the north a Middle Miocene belt contouring the eastern Puna boundary (Petrinovic et al. 2008). Its position, immediately to the SE of Cerro Galán, implies that this sector is appropriate for the production, storage and voluminous forming eruptions (> 100 km3) since ~13 Ma until at least 2 Ma (Cerro Galán: Sparks et al. 1985).

This is a contribution to PIP 5255 (CONICET) and PICT 2006-381 (ANPCyT) projects.

References

Baker M C W, Francis P W (1978) Upper Cenozoic volcanism in the Central Andes - Ages and volumes. Earth Planet Sci Lett 41:175-187

González O E, Viruel M E, Fernández D S (1999) El complejo piroclástico Cerro Tipillas en el borde oriental de la Puna Austral, Argentina, 14° Congreso Geológico Argentino (2):236 -239. La Plata.

Grier M, Dallmeyer R D (1990) Age of the Payogastilla Group: Implications for foreland basin development, NW Argentina. J South Am Earth Sci 3:269-278

Guzmán S, Petrinovic I. The Luingo Caldera (12 - 13 Ma): the first eruptive cycle in the Cerro Galán area (26º 10' S - 66º 40' W). Submitted to Bull Volcanol, Special

Issue on Cerro Galán System, Cas R and Cashman K (Eds)
Hongn F D, Seggiaro R (2001). Hoja Geológica 2566 – III. Cachi. Boletín Nº 248. Programa Nacional de Cartas Geológicas 1:250.000. SEGEMAR, Argentina
Marrett R, Allmendinger R, Alonso R, Drake R (1994) Late Cenozoic tectonic evolution of the Puna Plateau and adjacent foreland, northwestern Argentine Andes. J S Am Earth Sci 7 (2):179-207
Petrinovic I A, Hongn F D, del Papa C E (2008) Volcanismo Paleógeno - Neógeno y su relación con la tectónica en la Región Central de la Puna (~ 24°S). Actas del 17° Congreso Geológico Argentino (1): 229-230. Jujuy.
Schnurr W, Trumbull R, Clavero J, Hahne K, Siebel W, Gardeweg M (2007) Twenty-five million years of silicic volcanism in the southern central volcanic zone of the Andes: Geochemistry and magma genesis of ignimbrites from 25 to 27° S, 67 to 72° W. Volcanol Geotherm Res 166:17-46
Sparks R S J, Wilson L (1976) A model for the formation of ignimbrite by gravitational column collapse. J Geol Soc Lond 132:441-451
Sparks R, Francis P, Hamer R, Pankhurst R, O´Callaghan L, Thorpe R S, Page R (1985) Ignimbrites of the Cerro Galán caldera, NW Argentina. J Volcanol Geotherm Res 24:205-24.
Thorpe R S, Francis P W, O´Callaghan, L O (1984) Relative roles of source composition, fractional crystallization and crustal contamination in the petrogenesis of Andean volcanic rocks. Philos Trans R Soc (Lond) 310:675- 692

Lead isotopic fingerprints of fauna and crustal isotope domains as a basis for tracing origin and migration of prehistoric people in the Central Andes

Hartmann G, Mamani M, Wörner G

Abt. Geochemie, GZG, Universität Göttingen, Germany, ghartma@gwdg.de

The application of isotopic compositions to artefacts and human remains has been used to investigate the geographic origin of prehistoric people as well as their migration patterns. These studies rely on the hypothesis that isotopic ratios in tissues of regional flora, fauna and humans match with the isotopic ratios of the underlying soil, sediments and bedrocks. It is further assumed that isotopic ratios are not fractionated during biogeochemical processes and between trophic levels from plants to herbivores to small and large carnivores.

Contrary to Sr-isotopes, lead isotopes in faunal and human bone and especially tooth enamel have not been applied previously to reconstruct the provenance and mobility of people in the Central Andes. This study is aimed at testing the hypothesis that observed Pb-, Sr- and Nd-isotopic compositions of teeth enamel of llamas

and alpacas in the Central Andes, which exclusively feed from natural pasture, reflects the biologically available Pb-, Sr- and Nd-uptake from local bedrock soils during lifetime. We do so by comparing the isotope ratios measured in teeth from localities in southern Peru to northern Chile (14° to 22°S) with the isotope signatures of the bedrocks and sediments of the area under investigation. For this test and potential later application to human teeth and artefacts, the variations in crustal isotopic composition must be known over this area at high spatial resolution. Mamani et al. (2008, 2009) recently documented geochemical and isotopic (Pb-, Sr-, Nd-) variations for the central Andes based on a database of >1500 analyses for intrusive and volcanic rocks, sedimentary rocks as well as metamorphic basement. GIS-analysis of this extensive data set results in a high-resolution map of distinct (Pb- and Nd-) isotopic crustal domains in the Central Andes. The transition from one isotopic domain to another occurs between within only a few tenths of kilometres (e.g. at 16°S in southern Peru) up to 150 km (20°S in northern Chile) and this represents the maximal spatial resolution of any provenance study. For analysing the biologically available Pb isotope ratios in faunal tissue we collected tooth samples of modern alpaca and llama. For the characterisation of 206Pb/204Pb signatures we relied on tooth enamel because of its resistance to diagenetic contamination, while bone is highly susceptible to contamination from soil. These animals are excellent proxies to represent biologically available isotopes in a given region because they exclusively feed on local pasture. Other animals (e.g. donkey and cows) that feed on "imported" food or fertilized agricultural land are not useful for our purpose. Therefore, the results from these materials can be applied also to humans. Along with the animal remains we sampled a variety of fine sediments, soils, and salts in order to better define local average soil and bedrock isotope values. Marine mussel shells will represent imported food from the ocean. Pieces of locally produced ceramics of variable antiquity have also been sampled for comparison.
Samples from the "Cordillera Domain" (Mamani et al., 2008) come from the vicinity of Cuzco and Pisaq display 206Pb/204Pb ratios from 18.64 to 18.77 with values for ceramic materials for 206Pb/204Pb = 18.89). These values match the regional pattern extraordinarily well with respect to the Pb domain values from were the samples were derived.

Our samples from the Arequipa domain are surface sediments, teeth of llamas and other animals from the Las Salinas region and Cañon del Colca near Chivay and mirror the distinctly lower 206Pb/204Pb ratios from 18.1 to 18.45 of this region.

The southern Cordillera domain is located below the 22oS latitude with comparatively high values of the 206Pb/204Pb ratio from 18.5 to 18.9 and above.

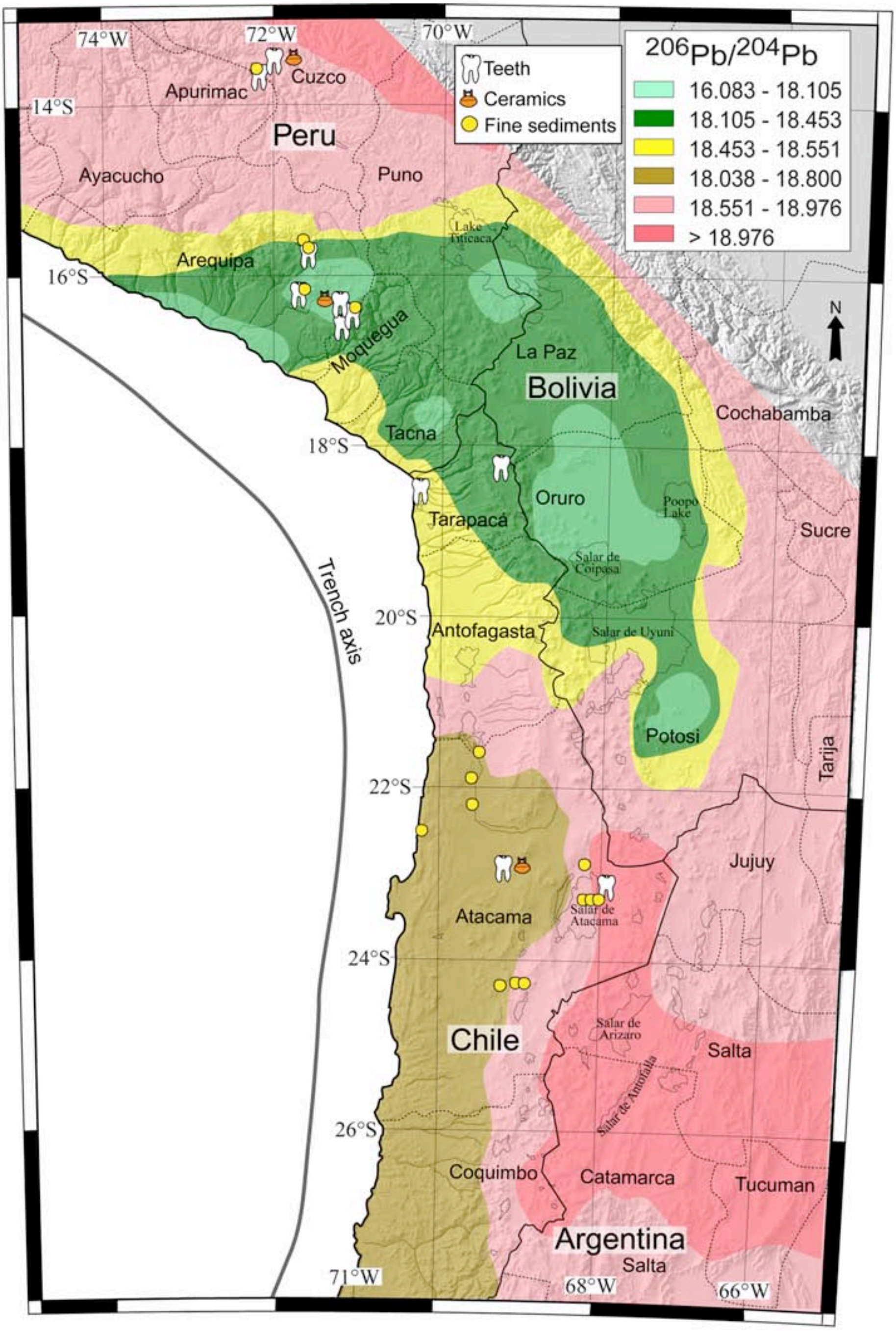


Figure 1: Crustal domains distinguished on the basis of present-day 206Pb/204Pb ratios (modified after Mamani et al., 2008a)

Sediment and teeth from east of the Salar de Atacama display 206Pb/204Pb ratios from 18.6 and 18.9. The Mejillonia and Chilenia Pb domains are located south of 22oS in northern Chile with typical local 206Pb/204Pb ratios from 18.0 to 18.85. Sediments, sands and salts sampled in the area of San Pedro de Atacama and the Chilean Longitudinal valley display 206Pb/204Pb ratios of 17.9 and 18.9. A ceramic shard from the "Pukará de Quitor", a pre-Columbian archaeological site in northern Chile, displays a 206Pb/204Pb ratio from 18.05 and thus may be of local origin.

In summary our data confirm (1) that lead isotopic ratios of teeth reflect the lead isotopic composition of the local soils, bedrocks and sediments, (2) the assumption that these animals were raised locally, (3) that this approach is highly promising in application to human artefacts and (4) that the ceramic samples were of local manufacture. Lead isotopes thus can give quite unambiguous information about the geographical origin of animals and ceramics. The forensic potential and usability of lead isotope analysis in teeth as illustrated here by faunal case studies suggests that it should be possible to trace human origin and migration in the central Andes with this method.

The Inca Empire is especially predestined for this kind of research. The Empire was a federalist system, consisting of provinces spreading across the investigated area. The spatial extent of the four provinces matches largely with the Pb-isotope domains of the central Andes. The determination of the lead isotopic composition of human teeth would offer the possibility to distinguish between local and non-local residents, to identify immigrants, and to determine places of origin and residential mobility. This method, when combined with genetic information on the human remains should also distinguish whether individuals migrated themselves or whether resident people were descendants of those who migrated.

References

Mamani M, Tassara A, Wörner G (2008) Compostion and structural control of crustal domains in the central Andes. Geochemistry Geophysics, Geosystems G3 9: 1-13

Mamani M, Wörner G, Sempre T (2009) Geochemical variations in igneous rocks of the Central Andean Orocline (13° to 18°S): Tracing crustal thickening and magma generation through time and space. Geological Society of America Bulletin. (in revision)

Combined U-Pb and Hf-isotope study on the Puncoviscana Formation in tastil area, Eastern Cordillera, Nw argentina: evidence for the Maximum and minimum age

Hauser N 1 2, Matteini M 1, Pimentel MM 1, Omarini R 2

1 Instituto de Geociências, Universidade de Brasília, hausernatalia@yahoo.com.ar
2 Universidad Nacional de Salta, Argentina-CONICET.

Combined U-Pb and Lu-Hf isotope measurements on representative sample (BTA 104) of the Neoproterozoic Puncoviscana Formation in the Santa Rosa de Tastil region, Eastern Cordillera (Fig. 1) allowed us to delineate the sources areas of these sediments. In the study area the already deformed Puncoviscana Fm. is intruded (Fig. 2) by the lower cambrian Grey granodiorite of the Tastil Batholith (Bachmann et al., 1987, Hongn et al., 200, Matteini et al., 2008). This permitted to define the maximum and minimum ages for the Puncoviscana Fm. in this sector of Eastern Cordillera.

The Puncoviscana Formation, with Late Neoproterozoic age (DoCampo et al., 1999) is characterized by a thick sequence (>2000m) of very low to low grade metapelite and turbidites (eg Jezek 1990; Omarini et al., 1999). Deposition and provenence areas of the Puncoviscana sediments have been discussed in several geochronological (Lork et al., 1990; Adams et al., 2008), petrological (Omarini, 1999; Jezek & Miller 1986) and geochemical (Willner et al., 1990; DoCampo and Gue-vara, 2005; Zimmermann, 2005) studies.

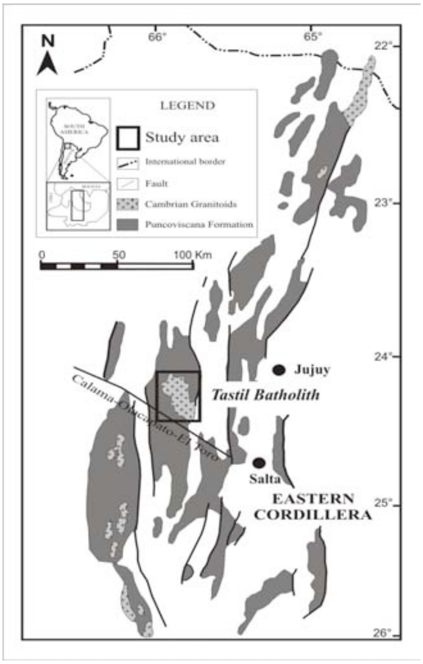


Figure 1: Outcrop area of the Puncoviscana Formation in NW Argentina. The cambriam granitoids are also shown (modified from Do Campo and



Figure 2: View of the intrusive contact between the Grey Granodiorite and turbidites of Puncoviscana Formation in the studied area.

LA ICPMS in situ U-Pb analyses have been carried out on 68 singles grains of sample BTA 104 (Fig. 3A). The age spectrum comprises minor peaks of Paleoproterozoic (between 1.7 and 2.0 Ga), Mesoproterozoic (between 1.0 and 1.1 Ga) and Neoproterozoic (~750 Ma) ages. The main peak, represented by more than 90% of analized zircons grains, is in the Late Neoproterozoic between 650 to 550 Ma. The age of 550 Ma is interpreted as the maximum age of sedimentation.

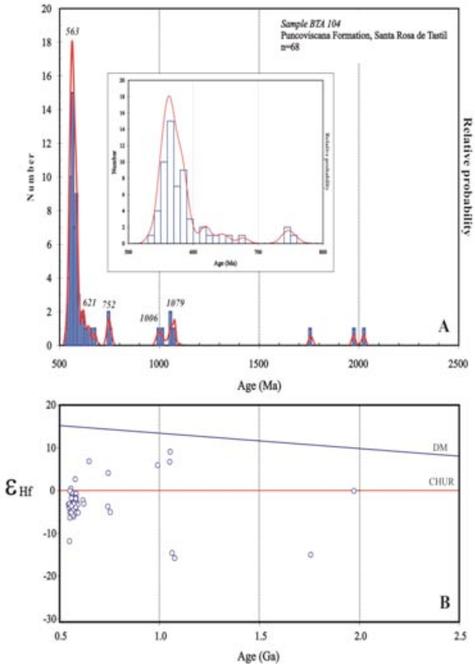


Figure 3: U-Pb concordian diagram and εHf-isotope diagram for the sample BTA

LA ICPMS in-situ Hf isotope analyses have been obtained on 59 zircon grains previously analyzed with U-Pb method (Fig. 3B). The zircon with paleoproterozoic ages (1.76 and 1.97 Ga) represent recycling of Paleoproterozic to Archean crust as indicated by T_{DM} of 3.0 and 2.5Ga. Zircons with U-Pb ages at ~1.0Ga present positive (+6.0 to +9.0) and negative (-15) εHf values, with T_{DM} of 1.3 Ga and 2.6 Ga respectively. The zircons with U-Pb ages at 750Ma display negative εHf values around -4.5, with T_{DM} of 1.7Ga whereas only one positive εHf value (+4.0), with T_{DM} approximately of 1.3Ga has been observed. The zircons with U-Pb ages from 650 to 550Ma show mainly negative εHf values ranging approximately from -6.0 to 0. Their T_{DM} are between 1.24 and 1.8Ga (Fig. 3c). One zircon with more negative εHf values (-12) and older T_{DM} (2.6Ga) are observed. Three analized zircons with positive εHf values (+0.35 to +7.0) present the younger T_{DM} (~1.2Ga).

The Paleoproterozoic zircon ages could represent the Trans-Amazonian Cycle. The zircons with Grenville ages (~1.0 Ga), are explained both by provenance from Mesoproterozoic orogens of the Brazilian Shield or from Laurentia (Grenville Orogeny), with generation of juvenil crust at 1.0 Ga as evidenced by the positive εHf values of three zircons. The zircons at 750 Ma indicate both a contribution of an Archean crust and of a juvenil component. The Hf-isotope compositions of zircons from the main peak suggest that zircon protoliths originating from both recycled crust and juvenile sources, during the installation of Pampean Arc.

The new data permit to define a maximum age of sedimentation for the Puncoviscana Formation in this sector at 550 Ma. The intrusion of the Grey granodiorite of

the Tastil batholith with known age of 535 Ma (Bachmann et al., 1987, Hongn et al., 2001, Matteini et al., 2008) strongly constrain the minimum age for these sediments. Therefore the sedimentation and deformation of Puncoviscana Fm. occurred in a very short lapse of time of approximately 15 Ma, between 550 Ma and 535 Ma, probably in an active continental margin.

References

Adams CJ, Miller H, Toselli AJ, Griffin W (2007) The Puncoviscana Formation of northwest Argentina: U-Pb geochronology of detrital zircons and Rb-Sr metamorphic ages and their bearing on its stratigraphic age, sediment provenance and tectonic setting. N Jb Geol Paläont Abh 24; Stuttgart.

Bachmann G, Grauert B, Kramm U, Lork A, Miller H (1987). El magmatismo del Cámbrico medio/Cámbrico superior en el basamento del noroeste Argentina; investigaciones isotópicas y geocronológicas sobre los granitoides de los complejos intrusivos de Santa Rosa de Tastil y Cañani. Actas Congreso Geol Argentino 4: 125–127.

Do Campo M, Riveiro Guevara S (2005) Provenance and tectonic setting of late Neoproterozoic metasedimentary successions in NW Argentina. J S Am Earth Sci 19: 143-153.

Do Campo M, Nieto F, Omarini R, Ostera H (1999). Neoproterozoic K–Ar ages for the metamorphism of the Puncoviscana formation, Northwestern Argentina, 2nd Simposio Sudamericano de Geología Isotópica, Argentina, Actas I: 48–53.

Hongn F.D, Tubıa J.M, Aranguren A, Mon R (2001). El batolito de Tastil (Salta, Argentina): un caso de magmatismo poliorogénico en el basamento andino. Boletín Geológico y Minero de España 112: 113–124.

Jezek P, Miller H (1986) Deposition and facies distribution of turbiditic sediments of the Puncoviscana Formation (Upper Precambrian-Lower Cambrian) within the basement of the NW Argentine Andes. Zentralbl Geol Palaeontol Teil I, 9/10: 1235-1244.

Lork A, Miller H, Kramm U, Grauert B (1990). Sistemática U-Pb de circones detríticos de la Fm. Puncoviscana y su significado para la edad máxima de sedimentación en la Sierra de Cachy (prov. De Salta, Argentina). In: Aceñolaza, F. G; Miller, H; Toselli, A. J; (Eds.), El Ciclo Pampeano en el Noroeste Argentino. Serie de Correlación Geológica N 4. Universidad de Tucumán: 199-208.

Matteini M, Hauser N, Pimentel, M.M, Omarini H.R, Dantas E.L, Buhn B (2008). Combined in situ U-Pb, Lu-Hf and Sm-Nd systematics applied to the Tastil Batholith, Eastern Cordillera, NW Argentina: implications for the evolution of western margin of Gondwana during the early Paleozoic. VI Simposio Sudamericano de Geología Isotópica, Bariloche, Argentina.

Omarini R., Sureda R., Götze H., Seilacher A, Plüger F (1999). he Puncoviscana folded belt: a testimony of Late Proterozoic Rodinia fragmentation and the collisional pre-Gondwanic episodes. Int Journ Earth Sciences 88: 76-97.

Willner AR, Miller H, Jezek P (1990) Composición geoquímica del basamento sedimentario/ metamórfico de los Andes del NW Argentino (Precámbrico Superior/Cámbrico Inferior). In: Aceñolaza FG, Miller H, Toselli AJ, (Eds) El Ciclo Pampeano en el Noroeste Argentino. Serie de Correlación Geológica N 4. Universidad Nacional de Tucumán: 161-179.

Zimmermann U (2005) Provenance studies of very low-to low grade metasedimentary rocks of the Puncoviscana complex, northwest Argentina. In Vaughan APM; Leat PT, Pankhurst RJ (Eds) Terrane processes at the margins of Gondwana. Geol Soc London, Spec Publ 246: 381-416.

From sink to source – Inferring onland geodynamics and sedimentary pathways from the marine and estuarine record – A detrital apatite fission track study from the Chile continental margin (29-47°S)

Heberer B 1, 2, Behrmann JH 3, Rahn M 1,4

1 University of Freiburg, Geological Institute, Germany, bianca.heberer@sbg.ac.at
2 University of Salzburg, Department of Geography and Geology, Austria
3 IFM-GEOMAR, Kiel, Germany
4 ENSI, Villigen-ENSI, Switzerland

A combination of apatite fission track (AFT) dating and sediment analysis was carried out on trench sands from gravity cores and estuarine sands of South Central Chile between 29° and 47°S to (a) obtain information on sediment provenance, present-day erosion patterns, tectonic processes in the source area and (b) to test detrital thermochronological concepts, such as the generally made assumption of a negligible transport time within the lag time concept. Detrital fission track analysis has become a powerful tool for the study of sediment provenance and exhumation of orogens. Many studies focus on zones of continental collision with no or little volcanic activity, but there are fewer examples from active arc-trench systems. This type of orogen has a strong magmatic signature, and upper plate tectonothermal histories that are distinct from collisional mountain belts. Uplift and denudation histories are different, and may comprise long periods of relative upper plate stability, which can be identified by thermochronological methods.

The selected Chilean margin segment area covers a ~1200 km long north to south transect encompassing areas of strongly variable characteristics, such as large latitudinal gradients in climate and terrigenous sediment input into the trench. The southern limit of the study area is located at the Chile Triple Junction, where the actively spreading Chile Ridge is subducted beneath the South American Plate.

Bulk samples were collected from major rivers with drainage systems encompassing the three main morphological units, i.e. the Main Andean Range, the Longitudinal Valley, and the Coastal Cordillera. Between 36° and 42°S the fluvial load of riv-

ers such as the Biobío is transported via submarine canyons to large trench fans. These proximal sites were preferentially targeted for gravity coring as they are not or only subordinately subject to the northward-directed material transport within the trench, and thus are expected to best reflect the source area. Additional marine samples were derived from turbiditic layers of the trench fill and slope sites. Inferences made from the regional information on sedimentation rates suggest that the cored sediments are of Holocene and (subordinately) of Pleistocene age.

Apatite FT age distributions from the trench fans and the estuaries were referred to their sources by comparing their single grain age distribution to the cooling age pattern of the bedrocks of the feeder area. Drainage systems were derived from digital elevation models and areal extents of units carrying a specific age signature were quantified. Thus we could denominate those units contributing to the flux of sediment to the basin, which seem to be over- or underrepresented in the river-mouth resp. trench fan sediment.

We find that AFT dating and sediment analysis (modal analysis, X-ray petrography) point to opposing major sediment sources at the Chilean margin: Whereas sediment petrography mirrors the evacuation of large volumes of volcanic detritus, reflecting the high rate of erosion of volcanic edifices, no such young volcanic signal is seen in the detrital AFT signature and the youngest detrital AFT population consistently yields a Late Miocene age. Plutonic units are identified as the main, often unique sources for shedding apatite into the sedimentary system. This finding has important implications for studies on stratigraphically older sequences, where the feeder area has long been eroded, and where the youngest age population is often interpreted as an indicator for active volcanism. In areas with a high density of published onland AFT ages, the detrital record is mostly in accordance with this data, corroborating the concept of a zero transport time. However, our study underlines that the detrital age pattern only grants a selective representation of cooling ages derived from (in parts) small erosional sources, whereas age signals from areally widespread geological units of volcanic origin are excluded from detection.

The most obvious feature of detrital FT analysis from marine as well as fluvial facies observed along-strike the Chilean margin are contrasting peak sizes, i.e. variable contributions of recognizable large-scale source areas (Andean and Coastal Cordillera) north and south of approximately 36°S. South of this latitude, a major Late Miocene age fraction is consistent with sources of equivalent age from the Andean Range. Only subordinate input with older AFT signatures comes from the Coastal Range. North of 36°S, the pattern is reversed. The observed asymmetry may be attributed to the first-order controlling parameter of variable apatite contents of the eroding units. It is thought to be additionally caused by the strong latitudinal variation of precipitation rates in the study area with decreasing rainfall and thus less erosion along the main Andean divide, in the northern part. Furthermore, the large fraction of apatites with a Coastal Cordilleran age signature and the dearth of young ages north of ~36°S may, at least partially, be a consequence of current strong uplift of the Coastal Cordillera. Although, tectonic and/or erosional exhumation since

~Upper Cretaceous times was not sufficient to be recorded by the AFT signal itself, i.e. was less than ~2-4 km, the relative size of the peaks allows the detection of short-term erosional and geomorphological processes. Results from detrital AFT analysis from the northernmost part of the study area (with so far no AFT bedrock ages available), permit to extend the hypothesis of long-term relative tectonic stability of the forearc northward since the uppermost Cretaceous, confirming that subduction erosion rather than tectonic accretion is the prevailing tectonic mode of this long-lived segment of the South American convergent margin.

For the southernmost study area in the Patagonian Andes, it can be shown, that the sediment is derived from only small portions of the drainage area located along the main Andean divide. This points to focused and rapid glacial erosion along the highest elevations. As already suggested on the basis of onland FT studies in the vicinity of the Chile Triple Junction at 47°S, substantial uplift of the forearc in response to active ridge subduction is not evident from the detrital perspective. Neither the AFT ages themselves, nor the relative proportions of the sources, argue for a strong denudational response of the upper plate to the subduction of the Chile Ridge.

Late Quaternary environmental dynamics of Amazonian rainforest in northern Brazil – New palynological insights

Hermanowski B 1, Behling H 1, Lima da Costa M 2

1 Department of Palynology and Climate Dynamics, Albrecht-von-Haller Institute for Plant Sciences, University of Goettingen, barbara.hermanowski@biologie.uni-goettingen.de
2 Centro de Geociencias, Universidade Federal do Pará, Belém*, Brazil*

Amazonia is the earth's largest rainforest ecosystem and plays a decisive role in global climate, hydrology cycle, and biodiversity. In our project we study late Quaternary environmental dynamics using several sediment archives from different regions north and south of the equator in the Brazilian Amazon region.

The first investigated cores of swamp and lacustrine sediments derive from a plateau of about 700 m asl, situated in the south-eastern area of Amazonia surrounded by humid tropical rainforest. Generally, the region is affected by the shifting of the Intertropical Convergence Zone (ITCZ) from its winter to its summer position. This crucial atmospheric system of low pressure and high precipitation is a relevant factor for Amazonian vegetation composition and several studies indicate a change in its mean positioning during the late Quaternary. Our preliminary results based on palynological and charcoal analysis provide new insights into vegetation and fire dynamics in this region throughout the late Quaternary. We are interested in the reconstruction of the ITCZ dynamic, and its impact on this tropical ecosystem as well as potential human impact. Likewise we study the timing of vegetation change, its driv-

ing forces and the response time of vegetation. Further on, we want to bring more clarity to the still intensely debated subject of the existence of glacial refugia in Amazonia, a hypothesis suggesting small islands of rainforest during the Pleistocene.

Significado y Alcances Estratigráficos de Deformación Post-Laramídica en la Región de Acapulco, Tierra Colorada y Chilapancingo: Estado de Guerrero Región Sur de México.

Hernández-Treviño T 1, Solis-Pichardo G 2, Schaaf P, Pérez Gutiérrez R 2, Torres de León R 2, Salgado Soto Z 3, Meza García VB 1

1 Instituto de Geofísica, UNAM, 04510 México, D.F. tht@geofisica.unam.mx
2 Instituto de Geología UNAM, 04510 México, D.F.
3 Comisión Federal de Electricidad, Departamento de geología, México, D.F.

El Cretácico superior en México está caracterizado por el registro de varios eventos geológicos que influyeron para que se modelara el paisaje continental actual Mexicano. El evento más relevante es la Orogenia Laramide que dejó como evidencia la Sierra Madre Oriental. Es una de las cadenas montañosas más grandes e importantes en México ya que atraviesa de Norte a Sur el 80 % del territorio mexicano. Esta Orogenia en México es caracterizada por el tren estructural que grabó en las rocas mesozoicas y algunos basamentos modelando en un 60 % el relieve morfo-estructural continental actual. En el sur del país las estructuras de esta deformación están orientadas dominantemente N-S y el alcance estratigráfico de deformación solo es en rocas mesozoicas y algunas partes de las rocas basales.

En la margen pacífica sur en la región de Acapulco, Tierra Colorada y Chilpancingo hemos reportado un evento de deformación post-laramídico que evolucionó entre 50 y 40 millones de años y afectó a rocas paleocénicas y mesozoicas, dejando evidencias de pliegues y cabalgaduras con rumbos E-W y vergencias hacia el sur. Este patrón estructural y alcance estratigráfico distingue a esta deformación post laramídica de la laramídica. Ambas deformaciones alcanzan registro en la columna estratigráfica mesozoica de origen marino. Sin embargo, la deformación post-laramídica afecta rocas paleocénicas de origen continental (lechos rojos) de las formaciones Agua de Obispo y Balsas. Resaltamos que las estructuras primarias de depósito de estas formaciones son discordantes a las estructuras de la deformación laramídica. Para confirmar la existencia de esta deformación realizamos estudios geocronológicos de ambas formaciones, obteniendo edades de 56.3 ± 1.4 Ma por el método de K-Ar en micas. Por el método de U-Pb en circones obtuvimos dos edades: una de 51.4 ± 0.97 Ma y otra de 49.89± 0.8 Ma. Estas edades son clave en el entendimiento de los alcances estratigráficos de la deformación en cuestión.

Consideramos importante reconocer el alcance regional de esta deformación post-laramídica, en particular, la región que es paralela a la margen pacífica de los estados Guerrero y Oaxaca; ya que, si es consistente, podríamos intentar correlacionarla con la reconstrucción del sur de México en los últimos 60 Ma. El análisis de esta deformación post-laramídica podría servir para aclarar, por ejemplo, el cuestionamiento del paso del Bloque Chortis sobre esta margen.

The age, nature and significance of the basement rocks of the Magallanes basin and of Cordillera Darwin, Tierra del Fuego, Chile: a SHRIMP U-Pb study of igneous and detrital zircons.

Hervé F 1, Calderón M 1 3, Fanning M 2, Kraus S 4, Pankhurst RJ 5, Mpodozis C 6, Klepeis K 7, Thomson S 8

1 Depto de Geología, Universidad de Chile, Casilla 13518, Correo 21, Santiago, Chile, fherve@cec.uchile.cl
2 Research School of Earth Sciences, Australian National University, Canberra, Australia
3 Servicio Nacional de Geología y Minería, Av. Santa María 0104, Santiago, Chile
4 Instituto Antártico Chileno, Plaza Muñoz Gamero 1055, Punta Arenas, Chile
5 British Geological Survey, Keyworth, Nottingham NG12 5GG, United Kingdom
6 Antofagasta Minerals (formerly at SIPETROL)
7 Department of geology, University of Vermont, Burlington VT 5405, USA
8 Arizona State University, Tucson.

U-Th-Pb age determinations on zircons from five orthogneisses rocks belonging to the Tierra del Fuego Igneous and Metamorphic Basement Complex (TFIMC), obtained from the bottom of oil wells in the Magallanes Basin have been performed by SHRIMP. Three of the samples yielded single ages interpreted as indicating Early Cambrian igneous crystallization of the host rocks, similar to the ages previously obtained by Söllner et al (2000) and Pankhurst et al (2003). A further migmatitic gneiss shows a peak of ca. 1000 Ma zircons, in addition to the Cambrian peak, suggesting involvement of Grenvillian crust in the formation of the migmatite in Cambrian times. A cordierite-sillimanite-garnet gneiss, has, in addition to a population of igneous zircons of Cambrian age, a population of U-rich metamorphic Permian zircons, indicating that a Permian high grade metamorphic event affected the Cambrian igneous rocks. Cambrian plutonic rocks are known from northwestern Argentina, the basements of the Sierra de la Ventana and, the Cape Fold Belt in South Africa and the Ross orogen in Antarctica, and are the results of the early stages of the formation of the Terra Australis orogen. The Permian metamorphic event is coeval with the deformation and low grade metamorphism of the sedimentary successions which overlie the basement in the above mentioned areas

In contrast, the Cordillera Darwin Metamorphic Complex, is composed of Paleozoic basement rocks, a mid Jurassic and younger volcano sedimentary cover, and Jurassic plutonic rocks that were metamorphosed together during the Cretaceous. The study of detrital zircons in the metamorphic rocks reveals a big difference in zircon age patterns with the coastal accretionary complexes of the Patagonian Andes with which they had been previously correlated. The patterns ressemble more those of the Eastern Andes Metamorphic Complex (Herve et al, 2003), which apparently developed in a passive margin setting (Faundez et al, 2001; Augustsson and Bahlburg, 2007). Also, the age distribution of the detrital zircons, indicate that the mainly Cambrian basement of the Magallanes basin, was not the main source of detritus for the protolith of the Cordillera Darwin basement. The detrital zircon ages also allow to establish that part of the amphibolite facies metamorphic rocks in Cordillera Darwin, have a Jurassic protolith. The possibility that the Magallanes Fagnano Fault Zone and the Magallanes Fold and Thrust Belt were developed near to the site of an older suture zone that separated the basements of eastern Tierra del Fuego and Cordillera Darwin is envisaged.

In Tierra del Fuego, at least 15 km of cover rocks were removed since the high grade Permian metamorphic episode and the uncomformable deposition of the Tobífera Formation in the Middle to Late Jurassic. This area should consequently be an important source of detritus for the conglomeratic Permian, and Triassic? successions in neighbouring regions in South America, in Africa and in Antarctica.

Acknowledgements: Empresa Nacional de Petróleos (ENAP) geologists Gastón Romero and Alvaro Chávez generously provided the samples from the bottom of oil wells in Tierra del Fuego. Fondecyt projects 1050431 and 7070092, as well as M. Fanning's research funds supported this research. Yachts Penguin, Foam and Chonos and their crews took us to these remote areas.

References

Augustsson, C. and Bahlburg, H., (2007). International Journal of Earth Sciences (Geologische Rundschau) DOI 10.1007/s00531-006-0158-7.

Faundez, V., Hervé, F. y Lacassie, J.P. (2002). Provenance studies of pre-late Jurassic metaturbidite successions of the Patagonian Andes, southern Chile. New Zealand Journal of Geology and Geophysics. Vol. 45, N4, p. 411 – 425.

Hervé, F., Fanning, C.M., Pankhurst, R.J. (2003). Detrital Zircon Age Patterns and Provenance in the metamorphic complexes of Southern Chile. Journal of South American Earth Sciences, Vol.16, 107 123.

Pankhurst, R.J., Rapela, C.W., Loske, W.P., Marquez, M. & Fanning, C.M. (2003). Chronological study of the pre-Permian basement rocks of southern Patagonia. Journal of South American Earth Sciences 16, 27-44.

Söllner, F., Miller, H. & Hervé, M. (2000) An Early Cambrian granodiorite age from the pre-Andean basement of Tierra del Fuego (Chile): the missing link between South America and Antarctica?, Journal of South American Earth Sciences 13, 163-177.

Altitudinal forest line shifts, climate change, and land-use impact in northern Ecuador during the last 3 millennia: implications for Kyoto-protocol driven carbon sequestration projects

Hooghiemstra H, Moscol Olivera M, Bakker J, Cleef AM, Duivenvoorden JF

IBED, University of Amsterdam, Netherlands, H.Hooghiemstra@uva.nl

The Ecuadorian Andes is inhabited for almost two millennia and the cumulative human impact on the landscape is dramatic. The Central Valley is fully deforested and there is no knowledge how the various vegetation belts were distributed under undisturbed and natural conditions. The upper forest line (UFL) is the transition from continuous 'upper montane forest' to open 'tropical alpine grasslands' (páramo). The natural position of the UFL is disputed: hypothesis-1 assumes a UFL at 4000-4100 m (Largaard 1992), and hypothesis-2 assumes a natural ~UFL at ~3700 m (Wille et al., 2002; Bakker et al., 2008). Implications are significant: under hypothesis-1 Kyoto Protocol-driven carbon sequestration projects may establish forest plantations up to at least 4000 m elevation. Under hypothesis-2 such policy results in destruction of the natural páramo ecosystem and plantations reflect afforestation instead of reforestation.

Altitudinal vegetation distribution in Guandera Biological Reseve (0°36'N, 77°42'E) was studied along a forest transect from 3300-3700 m which crossed the UFL (Moscol Olivera & Cleef 2009a). Difference in vascular plant species composition and structure revealed 2 communities in the forest. Forest patches in páramo between 3550 and 3700 m are similar to the continuous high Andean forest below the UFL. This indicates that forest patches now at ~50 m above the UFL have separated relatively recently from the continuous forest, or that forest patches can be easily colonized by direct input from the high Andean forest belt. It is suggested that the present-day sharp and abrupt UFL at 3640 m results from frequent and extensive burning. Under undisturbed conditions the UFL is probably at slightly higher altitude. In the páramo we examined 100 plots of zonal and azonal vegetation between 3400-4000 m (Moscol Olivera & Cleef 2009b). 3 Associations characterised the zonal páramo and 3 associations the azonal bog vegetation. Absence of structural subpáramo communities suggests fires were frequent and affected the páramo-forest transition intensively resulting in sharp discontinuities at the UFL. The process of disappearance of the subpáramo was also monitored from series of aerial photographs in the Colombian Andes (Van der Hammen 2002) making calibration of pollen records with modern altitudinal vegetation distribution a risky methodology. Evidence from modern pollen rain analysis showed how the vegetation is represented in pollen spectra (Moscol et al., in review). Characteristic páramo taxa are Poaceae and *Puya*, characteristic forest representatives are *Clusia, Hedyosmum*, Melastomataceae, and *Weinmannia*. Asteraceae and Ericaceae include many species ocurring in the páramo and in upper montan forest and reflect a broad altitudinal interval crossing the UFL. Records of *Hedyosmum* and arboreal taxa from the lower montane

forest (e.g. *Cecropia*) are over-represented in the páramo. *Rumex* in particular is an indicator of agricultural land. With increasing proportions of arable land in the study area the methodology to calibrate pollen records by modern pollen rain spectra is loosing relevance.

Pollen analysis of a 90-cm long sediment core from a small mire showed a record of vegetation change, climate change, and evidence of anthropogenic disturbance during the last 6000 years (Bakker et al. 2008). From 7150-6240 cal yr BP climatic conditions were cool and the UFL was at ~3100-3200 m. From 6240-5320 cal yr BP the UFL migrated upslope to 3600 m. From 5320-1050 cal yr BP the UFL was at 3600-3650 m. Species of *Hedyosmum, Weinmannia*, Melastomataceae, *Ilex*, Scrophulariaceae and *Symplocos* were most abundant in the upper motane forest. From 1050-860 cal yr BP the UFL dropped to 3350 m. From 860-600 cal yr BP cool climatic conditions prevailed and the UFL was around 3250-3300 m. Since ~600 cal yr BP evidence of agriculture (*Rumex*) is present and the UFL shifted upslope to 3600 m. During the last 150 cal yrs disturbance increased in the study area. The record shows that during the last 6000 years the UFL reached a maximum altitude of ~3650 m and we conclude that páramo grasslands above this elevation represent a natural ecosystem. Our conclusions should give direction to reforestation activities which are without justification currently partly implemented at elevations where páramo is the natural vegetationbelt.

We concluded that under natural conditions the UFL lies without doubt at maximally ~3700 m. Anthropogenic fire, cattle grazing, and collection of fire wood has lowered the natural UFL by some 50 m. The view that anthropogenic deforestation and expansion of agricultural land use during the last centuries in particular allowed the páramo to extend ~300-400 m downslope (a process called 'paramización') is rejected. Therefore, the presence of forest plantations (of rapidly growing exotic trees such as Mexican *Pinus*, Australian *Eucalyptus*, and *Acacia*) at elevation above 3700 m is discreditable and this Kyoto Protocol driven practice is destructing a natural, fragile, and biodiverse high Andean ecosystem.

References

Bakker J, Moscol Olivera M, Hooghiemstra H, 2008 Holocene environmental change at the upper forest line in northern Ecuador. The Holocene 18: 877-893

Largaard S, 1992 Influence of fire in the grass páramo vegetation of Ecuador. In Balslev H Luteyn JL (eds) Páramo; an Andean ecosystem under human influence. Acadmic Press London pp. 151-170

Moscol Olivera M, Cleef AM, 2009a Vegetation composition and altitudinal distribution of Andean rain forests in El Angel and Guandera reserves, northern Ecuador. Phytocoenologia in press

Moscol Olivera M, Cleef AM, 2009b A phytosociological study of the páramo along two altitudinal transects in El Carchi Province, northern Ecuador. Phytocoenologia in press

Moscol Olivera M, Duivenvoorden JF, Hooghiemstra H, in review. Pollen rain and pollen representation across a forest-páramo ecotone in northern Ecuador. Rev Palaeobot Palynol

Van der Hammen T, Pabón Caicedo JD, Gutiérrez H, Alarcón JC, 2002 El cambio global y los ecosistemas de alta montaña de Colombia. In Castaño Uribe C (ed) Páramos y ecosistemas alto andinos de Colombia en condición hotspot y global climatic tensor Ministerio del Medio Ambiente IDEAM Bogotá Colombia 163-209

Wille M, Hooghiemstra H, Hofstede R, Fehse J, Sevink J, 2002 Upper forest line reconstruction in a deforested area in northern Ecuador based on pollen and vegetation analysis. J. Trop. Ecol. 18: 409-440

Climate change and basin dynamics at 50-yr resolution during two glacial cycles (284-27 ka): a new record from Lake Fúquene

Hooghiemstra H 1, Vriend M 1, Groot MHM 1, Bogotá-Angel RG 1, Van der Plicht J 2, Lourens L 3, Berrio JC 1 4, & other Fúquene Project members

1 IBED, University of Amsterdam, H.Hooghiemstra@uva.nl
2 CIO, Universitynof Groningen, Netherlands
3 Universityof Utrecht, Netherlands
4 University of Leicester, Dept. of Geography, UK

We collected 2 parallel 60-m long cores from Lake Fúquene (Eastern Cordillera of Colombia, 2540 m alt. 5°N, 73°W) with the aim to assess north Andean climate variability, and biotic and abiotic changes in the basin at <100-yrs resolution. We analysed all proxies at 1-cm distance along the core. We constructed an almost uninterrupted composite record (Fq9C) on the basis of lithology, granulometry, and geochemical data (Fe, Ti, Zr).

We discuss the challenges and dangers of developing age models for long lacustrine sedimentary records. We applied the often used method of visual curve matching and a more independent method which first applies a spectral analysis in the depth domain. Method-1 included a set of 46 bulk sediment humic acid extract radiocarbon samples from the most carbon-rich intervals of sediment core Fúquene-9C which showed several chronological inversions. Lacustrine sediments from this relatively large montane basin at near equatorial latitudes suffer from low inputs and/or preservation of organic carbon during most of the time represented. This results in significant uncertainties for most of the radiocarbon age estimates. A hybrid geochronological framework, incorporating two bracketing radiocarbon age estimates, and multiple visually identified tie-points between the Fúquene-9C arboreal pollen record and the proximal well-calibrated chronology from the Cariaco Basin (Peterson et al., 2000; Palaeo3:234:97-113) was developed. This sedimentary

age model for the upper 26 m of the core indicated an age interval from 28 ka to 59.5 ka. Method-2 used spectral analysis in the depth domain to detect the orbital cycles in the arboreal pollen record. Frequencies in the obliquity band dominated and were used to link the Fúquene-9C pollen record to the well-dated LR04 benthic ∂18O record (Lisiecki and Raymo 2005; Paleoceanography 20:PA1003). The age model based on this more independent method showed an age of 27 ka to 133 ka for the same core interval. We address problems arising from radiocarbon dating, compare both methods of developing an age model, and provide conclusions with particular relevance for long continental Pleistocene records of climate change.

The record reveals dominant frequencies in the 100 and 41-kyr bands, indicating that temperature changes in this tropical region are primarily glacial-interglacial paced. The absence of a significant precession signal (23 and 19 kyr bands) is explained by the minor seasonal migration of the Intertropical Convergence Zone in this region. In addition, we show that temperature has varied on millennial time scales up to 5ºC in concurrence with the Dansgaard-Oeschger (DO) cycles from Greenland, indicating the remarkable high sensitivity of the tropical high altitudes to abrupt climate changes in the North Atlantic region.

Apart from regional pollen (reflecting forest and páramo dynamics) we studied local pollen (aquatics), grain size distributions, organic carbon (LOI), and a suite of XRF-measured geochemical elements with the objective to better understand links between regional environmental change and the coeval dynamic processes in the basin itself. We applied the End-Member Modelling Algorithm (EMMA) for the first time to lacustrine sediments. In the 4768-points time series we showed that 4 grain size classes, here called end-members (EMs: clay, fine silt, coarse silt, and sand) explains an optimal proportion (70%) of the observed variation. EMMA is able to unmix GSD of lacustrine sediments in a genetically meaningful way. This means that categories (EMs) can be interpreted in depositional and environmental settings of the past. Most unexplained variability is located in the fraction of coarse sediment. Downcore variability reflects changing source areas of the sediments (from proximal to distal in relation to the drilling site), and available energy to transport sediments in the catchment area. We compensated for the absence of an estimate for the abundance of organic matter (including peat) in EMMA, which is problematical in lacustrine sediments, by artificially creating a fifth end-member on the basis of LOI data. We grouped pollen of quatics into 4 categories (deep water, shallow water, swamp, wet lake shores) and reconstructed lake-level variations. Periods with characteristic sedimentological regimes are 284-243 ka (mainly MIS 8) 243-201 ka (mainly MIS 7), 201-179 ka (mainly MIS 7/6 transition), 179-133 ka (mainly MIS 6), 133-111 ka, (mainly MIS 5e) 111-87 ka (mainly MIS 5d-5b), 87-79 ka (mainly MIS 5a), 79-62 ka (mainly MIS 4), and 62-27 ka (MIS 3). We demonstrate that the combination of biotic and abiotic proxies, and applying EMMA methodology, reconstructions of changes of sedimentary regimes and lake-level reconstructions improve significantly. We used the most recent 27 kys of pollen record Fq-2 (Van Geel & Van der Hammen 1973; Palaeo3 14:9-92) to extend our Fq9C record up to the present (record

FqBC). We assessed the global relevance of climate variability in record FqBC by comparison with (a) the LR04 benthic ∂18O record (Lisiecki and Raymo 2005), (b) the ~120 ka long NGRIP ∂18O record (NGRIP Community members 2004; Nature 431:147-151), (c) the ~90 ka long ODP Hole 1002C reflectance record of the Cariaco Basin (Peterson et al. 2000), (d) the Antarctic >284 ka long ∂Dice EPICA Dome C record (Jouzel et al. 2007; Science 317: 793-795), and (e) the >284 ka long MD01-2444/2443 SST record from the Iberian Margin area (Martrat et al.; Science 317:502-507). The well documnted 26 DO-cycles of the last glacial cycle (MIS 5-2) are reflected in detail in the pollen-based record of climate change. Our record shows 20 DO-style cycles in the previous glacial cycle (MIS 7-6) and confirmed the sequence of climatic oscillations observed in the Iberian Margin.

References

Bogotá-Angel RG, Hooghiemstra H, Berrio JC, Giraldo C, Gonzalez N (in review). Submillennial-scale climate variability, vegetation dynamics, and changing sedimentary regimes during MIS 8-6 from Lake Fúquene, Colombia. Review of Palaeobotany and Palynology

Bogotá-Angel RG, Groot MHM, Hooghiemstra H, Berrio JC (in review) Late Pleistocene sediment infill of the Fúquene Basin (Colombian Andes) from 4 pollen records and global significance of the centennial-resolution climate climate variability. Journal of Quaternary Science

Groot MHM, Bogotá-Angel RG, Lourens LJ, Hooghiemstra H, Vriend M Berrio JC, Van der Plicht J, other Fúquene Project members (in review). High-resolution 284-kyr terrestrial record reflects low latitude climate change driven by obliquity forcing. Science

Groot MHM, Van der Plicht J, Hooghiemstra H, Van der Linden M, Lourens L Rowe H, Berrio JC, Vriend M (in review) Establishing an age model fror Pleistocene lake sediments: a comparison of methods in the case study of the Andean Fúquene Basin, Colombia. Quaternary Geochronology

Groot MHM, Hooghiemstra H, Berrio JC, Giraldo C, Vriend M (in prep.) Submillennial-scale climate variability, vegetation dynamics, and changing sedimentary regimes during MIS 8-6 from Lake Fúquene, Colombia. Review Palaeobotany Palynology

Sarmiento G, Gaviria S, Hooghiemstra H, Berrio JC, Van der Hammen T 2008 Landscape evolution and origin of Lake Fúquene (Colombia): tectonics, erosion and sedimentation processes during the Pleistocene. Geomorphology 100: 563-575

Vriend M, Hooghiemstra H, Berrio JC, Groot MHM, Bogotá-Angel RG (in review) A geochemistry, granulometry and lithology based reconstruction of the intraAndean Fúquene Basin (Colombia) during the last two glacial cycles; sedimentary regimes and lake-size changes from a composite record. Palaeogeography Palaeoclimatology Palaeoecology

Vriend M Groot MHM Hooghiemstra H Bogotá-Angel RG Berrio JC (in review) Changing depositional environments at submillennial time-scales during 284-27 ka from combined unmixed grain-size distributions and aquatic pollen: the Colombian Fúquene Basin. Quaternary Science Reviews

Contamination by mineralogical dust emission of Si and Fe-Si industry in the region of Pirapora and Várzea da Palma, MG, Brazil, and its ambiental and health effects

Horn AH 1 Baggio H 2, Trindade WM 1, Braga LL 1

1 Núcleo de Geoquímica Ambiental – Instituto de Geociências - Universidade Federal de Minas Gerais - NGqA-CPMTC-IGC-UFMG – Brazi,l hahorn@ufmg.br
2 Laboratório de geologia e geomorfologia-Universidade Estadual de Montes Claros - LGG/NPA-UNIMONTES - Brazil, hernandobaggio@yahoo.com.br

Introduction: During the decades of 70th and 80th, six great industrial plants for the production of pure Si and Si-Fe compounds and leagues were constructed in the surroundings of the cities of Pirapora and Varzéa da Palma.
The area in study is located within the municipal districts of Varzéa da Palma and Pirapora, inserted in the Northern part of the Minas Gerais State, between the right margin of the middle São Francisco River and the left margin of the das Velhas River, a micro region which is covered by Cerrado and Caatinga Biotopes.
The area is delimited by the UTM coordinates: 52000E/8602000N and 532000E/8052000N and about 355 km from Belo Horizonte, the capital of Minas Gerais State.

The industrial process: The production process happens at high temperatures (about 800-1400°C), in charcoal heated ovens. The different raw materials are melted, mixed, reduced and mold in ingots, that will be crushed down and suffer sieve classification down to a granulometry in agreement with the specification of the use of the final product. Commercialization of these materials is divided between exportation (70%) and the internal market (30%).
The reactions of those processes are based on the following equations:

$Fe_2O_3 + 2SiO_2 + 7C \rightarrow 2FeSi + 7CO$ - producing iron-silicon compounds

$SiO_2 + 2C \rightarrow Si\ (75\%) + 2\ CO_2$ - producing metallic silicon

The raw materials for the process are quartz from veins, iron oxides and hydroxides (goethite, hematite e.g.), barite, limestone, scrap metal and sometimes argillites and manganese oxide.
Products of dust emission: This proceeding creates a wide variety of gases, liquids and solid particles liberated in the surrounding air, causes by crushing, sieving, and transport and much more in the proper production process. The last one gives an output by the chimneys and directly by the open ovens. This output contains great amounts of solids, liquids and gaseous products. The cleaning processes of this mixture are very precarious, rudimentary and insignificant and proceeds by using mango filters and partially cyclones.

Composition of the dust: The formed smoke is principally of two distinct varieties, one

white principally amorphous material (>SiO_2) and one dark one of crystalline materials (~90%SiO_2, ~10%Fe_3O_4).
Gases are principally CO_2, CO, SO_2, H_2O and sometimes more complex N-C-S-O compounds. The *liquids* are acid drops of H_2SO_4, H_2CO_3 and more complex organic-compounds. The *solids* are formed by amorphous and crystalline SiO_2 and Fe_2O_3, pure Si, C, argillite and a variety of mixed particles of organic-metallic composition with different concentrations of adsorbed heavy metals.

Observations and results: Through the analysis of optical sweeping, it was observed two types different from particulates, a white one composed by amorphous silica and a silica darkness and crystalline magnetite.
The continuous and direct contact with this atmospheric pollution, brings serious problems to agriculture, animals and the population. Problems to agriculture were investigated in the Varzeá da Palma region were problems . Soil contamination by heavy metals (Co, Cd, Cr, Ni, Cd and even Be) were found together with thick particle deposits on plants difficulting their photosynthesis. We expect the same results for Pirapora and Buritizeiros.

Further investigations: Another relevant factor is temporality of the effects of the concentrations of those you nourish in the human organism, since the studies appear that the damages to the health begin starting from 30 years of exhibition; what appears for the need of defining studies seeking to obtain better results as for the prevention of the next generations. Investigation of health impact on the local population by questionnaires, respiration test, skin surface sampling and urine, probably confirming first impressions.

Suggestions: This research tries to answer these inquiries and it may be the base for the implantation of a prevention system of the population health, since the knowledge of the characteristics and of the behavior of those pollutant ones it will allow a more expressive action close to the environmental legislation.
Therefore, the results can subsidize actions that can maximize the use of the resources for the industrial activities as well as the initiatives of improvement of the process to assist the justness socio-ambiental.

Acknowledgements to FAPEMIG, UFMG, CPMTC, UNIMONTES

References

Cortecci, G (2006) Geologia e Saúde. Dipartimento di Scienze della Terra Geologico-Ambientale. Università degli Studi di Bologna. Trad. Wilson Scarpelli, São Paulo, Brasil.Disponível em: http://www.cprm.gov.br/pgagem/geosaude.pdf" 2006.

Braga LL(2007) A avaliação do impacto ambiental da usina de beneficiamento de minerais de Fe e Si, Várzea da Palma, MG, Brasil – Distribuição e transporte dos contaminantes. Dissertação (Mestrado em Geologia) Instituto de Geociências - Universidade Federal de Minas Gerais 81 p.

Novontny V (1995) Diffuse Sources of pollution by Toxic Metal and Impact on

Receiving Waters. In: Salomons W. *Heavy Metals: Problems and Solutions.* 4. ed. New York: Springer, Cap. 3, p. 32-52.
Morgan WKC, Reger RB, Tucker DM (1997) Health effects of diesel emissions. Ann. Ocup. Hyg., Vol. 41/6: 643-698.
Shu J, Dearing JA, Morse AP, Yu L, Yuan N (2001) Determining the sources of atmospheric particles in Shanghai, China, from magnetic and geochemical properties. Atmospheric Environment, 35: 2615-2625.

Preliminary interpretation of GPR-Profiles executed on three selected Veredas in the Rio Formoso Sub basin of the São Francisco Basin, MG, Brazil

Horn AH 1, Aranha PA 1, Baggio H 2, Palmares P 1, Trindade WM 1

1 Centro de Pesquisa Prof. Manoel Teixeira da Costa – Instituto de Geociências – Universidade Federal de Minas Gerais - CPMTC-IGC-UFM,G hahorn@ufmg.br
2 Campus Pirapora – Universidade de Montes Claros – UNIMONTES

Introduction: Geographically, the sub-basin of the Formoso River is positioned in the Southwest portion of the municipal district of Buritizeiro, and delimited by the coordinates of 17° 25' and 17° 56' latitude S and 44° 56' and 45° 26' longitude W; draining an area of 826 km² and integrating into Rio San Francisco hidrografic basin. Geologically and geo-morphologically, the basin belongs to the southern part of the "Sanfranciscana Basin" unit within the limits of the Cretaceous covered part of the San Francisco Craton. Generally presents SW-NE orientated structural features and is built up from the base for the top by the following sequences:
Alluvial sediments and alluvial terraces of Quaternary/Tertiary (acted by valleys and terraces - 600 m/alt to 470 m/alt);
Bambuí Group rocks of the Neoproterozoic Três Marias Formation, expressing in the relief a morphology of hills and hills - 850 m/alt to 600 m/alt);
Sandstones of the Areado Group (Lower Cretaceous) - Três Barras Formation and do Mata da Corda Group (Lower to upper Cretaceous) Formation and finally
Cenozoic Cover (undifferentiated) between 950 m and 850 m forming the well known "Chapada - planes" morphology.

Field work: There were executed six profiles with GPR between 50 and 200m. Two cross sections (one transversal and the other longitudinal) for the three selected veredas. After cleaning the selected regions, the work was done with a GPR from the Geophysic workgroup with appropriate antenna. Lectures were done every 10 cm. The obtained data were interpreted using xxx programs to obtain diagrams and statistical procedures to verify the data.

Results: All the interpreted cross section show similar behavior. They show a widely fractures rocky basement with an upper alterated part (weathering crust – laterite or

similar) covered by younger "vereda" sediments (argillites, arenites etc.,) semi consolidated to consolidated. Some profiles show subsequent introduction of some colluvian fans (?) in an interlayer texture with normal fluvial sediments with smaller cross stratification introduced by the river which cut the veredas. Sometimes bigger stratification indices wind deposition. Some peculiar perturbations of the normal layering indicate tectonic or consolidation caused slumping structures into the "vereda" basins.

Conclusions: The GPR profiles show normal sedimentation conduction, reflecting changes in climate and water transport and also uplift movements in this part during sedimentation which changes flux directions.

Acknowledgements to FAPEMIG, CNPq, CPMTC, Post-Graduation in Geology

References

Ab`Saber AN (1971) A organização natural das paisagens inter e subtropicais brasileiras In: Simpósio do Cerrado. São Paulo: Brasil.

Baggio HF, Horn AH, Trinidatde WM, Riberiro EV (2006) Grupo Mata da Corda na Bacia Hidrográfica do Rio do Formoso e suas Feições Morfológicas Correlata. VI Simp Nacional de Geomorfologia Regional Conference on Geomorphology.

Castro PTA (1997) Os conglomerados da borda SW do Cráton do São Francisco junto à porção S da Faixa Brasília: Sedimentologia e relações estratigráficas com as rochas do Grupo Bambuí. 1997. 264 p. Tese (Doutorado em Geologia) - Inst. De Geociências, Universidade de Brasília – UNB. Brasília.

Castro PTA, Dardenne MA (2000) The sedimentology, stratigraphy and tectonic context on the São Francisco Supergroup at the southwestern domain of the São Francisco Cráton, Brazil. Rev. Bras. Geociências, 30 (3): p. 439-441.

Chang AK, Miranda FP, Magalhaes L, Alkim FF (1988) Considerações sobre a evolução tectônica da Bacia do São Francisco. In: SBG, Congr. Bras. Geol., 35, Belém, Anais, 5: p. 2076-2090.

Chiagegatto JRS (1992) Análise estratigráfica das seqüências tempestística da Formação Três Marias (Proterozóico Superior), na porção meridional da Bacia do São Francisco. 1992. 216 p. Dissertação (Mestrado em Geologia) - Dep. de Geologia - Escola de Minas, Universidade Federal de Ouro Preto – UFOP. Ouro Preto.

Kimng LC (1956) A Geomorfologia do Brasil Oriental. Separata da Revista Brasileira de Geografia N.°- Ano XVIII – ABR/JUN. 1956. Rio de Janeiro, Instituto Brasileiro de Geografia.

Penha UC (2001) Geologia dos Conglomerados da Serra da água Fria e dos depósitos diamantíferos de Jequitaí, MG. 2001. 148 p. Tese (Doutorado em Geologia) Universidade Estadual Paulista – UEP. Rio Claro. São Paulo.

Sgrabi GNC (1991) Arenitos Eólicos da Formação Areado (Bacia Cretácea do São Francisco): Caracterização diagênese e aspectos.Revista Brasileira de Geociências. 21(4): p. 342-354.

Sgrabi GNC (2001) Bacia Sanfranciscana: o registro do fanerozóico da bacia do São Francisco. In: PINTO, C. P.; MARTINS-NETO, M. Bacia do São Francisco: Geologia e Recursos Naturais.Belo Horizonte. SBG-MG. p. 93-138.

Uhlein A, Fantinel LM, Batista MC, Lima ONB (2003) Contribuição à estratigrafia do Grupo Bambuí em Minas Gerais. In: SBG/Núcleo MG, Simpósio de Geologia de Minas Gerais, 12. Ouro Preto, Anais, CD rom.
Valadao RC (1998) Evolução de Longo-Termo do Relevo do Brasil Oriental (Denudação, Superfícies de Aplanamento e Soerguimento Crustais). 1998. 242 p. Tese (Doutorado) - Inst de Geociências. Universidade Federal da Bahia–UFB. Salvador.
Vianna V(2006) Estudo Hidrogeoquímico das Veredas do Rio do Formoso no Município de Buritizeiros, Minas Gerais. Dissertação (Mestrado em Geologia) – Instituto de Geociências - IGC/UFMG, Belo Horizonte: UFMG, 107 p.

Manejo sostenible de lentes de agua dulce en el distrito de Benjamin Aceval, Chaco Paraguayo

Insfrán A 1, Houben G 2, Rojas C 2, Silvero J 1

1 Secretaría del Ambiente de Paraguay (SEAM), Asuncion, insfrana_py@yahoo.com
2 Proyecto de Manejo Sostenible y Protección de las Aguas Subterráneas, PAS-PY

En el marco de la cooperación paraguayo-alemana, la Secretaría del Ambiente con el apoyo del Instituto Federal de Geociencias y Recursos Naturales de Alemania (BGR), llevan adelante el *Proyecto de Manejo Sostenible y Protección de las Aguas Subterráneas PAS-PY,* que tiene como una de sus áreas piloto el distrito de Benjamín Aceval. El municipio de Benjamín Aceval se encuentra a 42 km "http://es.wikipedia.org/wiki/Asunci%C3%B3n" en el Chaco Paraguayo. La mencionada zona forma parte del acuífero Patiño y la conforman areniscas, en parte metamorfizadas. La metamorfización es un resultado de intrusiones de basalto, las cuales dan lugar a cuarcitas y areniscas columnares. Debido a la dureza de las rocas metamorfizadas las areniscas sobresalen por sobre la planicie del Chaco en una zona de apenas 20 km^2.

A través de estudios de geofísica se han identificado varias lentes de agua dulce por debajo de la elevación, rodeada por agua salobre y salada en las zonas bajas circundantes. Se realizaron 11 km de perfiles geoeléctricos (WENNER) y 24 sondeos verticales electromagnéticos (TEM). La zona de agua dulce concuerda en gran parte con la zona urbana del distrito. De allí se abastece la población para el consumo humano de alrededor de 16.000 personas.

No existe planta de tratamiento de aguas cloacales en el distrito, situación que preocupa pues la zona urbana coincide en parte con áreas de recarga del acuífero. Se tomaron muestras de agua de todos los pozos profundos y se realizaron los análisis correspondientes, constatándose la presencia de coliformes en algunos pozos. Mediciones del caudal del Rio Verde completan los trabajos de campo. Todos estos estudios tienen como finalidad la elaboración de un plan de manejo sostenible del limitado recurso hídrico.

Los mapas de la distribución de agua dulce también sirven como base para la pla-

nificación urbana. En este sentido, el Proyecto PAS-PY trabaja en forma conjunta con el Proyecto ORDAZUR (Ordenamiento Ambiental de Zonas Urbanas). Planteada la situación natural y antrópica, se trabaja a través del proyecto en abordar las complejidades con las personas afectadas, teniendo como foco a los habitantes del Distrito de Benjamín Aceval a través del desarrollo local con la figura del "Consejo de Agua", involucrando a los actores naturales en el acompañamiento de la investigación de los recursos hídricos, la concienciación y la estimulación a la aplicación de ordenanzas municipales para la aplicación local de la ley de los recursos hídricos.

The formation of talus cones and scree slopes as result of the paraglacial landscape transformation in the Aconcagua-Massif (Argentina) and the Marmolejo Massif (Chile)

Iturrizaga L

Institute of Geography, University of Goettingen, Germany, liturri@gwdg.de

In the classical view of geomorphology, talus cones and slopes are mainly classified as periglacial landscape elements as products of frost weathering processes in the region of the Dry Andes. However, initial field observations in 2006 in the Aconcagua-Massif and in 2008 in the Marmolejo-Massif (32°30'-34°S) as well as the interpretation of satellite images indicates that the origin of a major part of the talus accumulations can be considered as primarily glacially-induced landforms. Therefore, their formation proves to be closely linked to the extent of the former glaciation. The Aconcagua-Massif and adjacent mountain ranges have experienced an extensive glaciation during the Last Glacial Maximum. At that time period, the main glacier in the Rio Mendoza valley at the Andes E-side reached down to an altitude of 1850 m with ice thicknesses of up to 1000 m and a length of up to 110 km (among others Brüggen 1929, Kuhle 1985, Espizúa 1993) and at the Aconcagua W-side down to an altitude at 1300 m (Brüggen 1929).

As in other glaciated mountain regions of the world, paraglacial processes play in the Andean mountain ranges a pivotal role in the landscape formation. However, in the subtropical latitudes paraglacial processes are closely amalgamated and interfere with weathering processes (frost, insolation and salt weathering) and can be easily misinterpreted in terms of their origin. The primary factor controlling the occurrence of talus cones is the specific distribution of the pleistocene glaciation. Basically, the Rio Mendoza valley in the Aconcagua-Massif and its tributary valleys as well as the Rio Maipo valley have been glacially-oversteepened and provide therefore favorable conditions for the development of talus accumulations. Pressure release and loss of support owing to melting ice has lead to diverse forms of collapse failures at the valley flanks, which show convergent forms to talus cones formed by frost-weathering processes. This is not only the case in the recent glacier forefields, where talus cones are a common landscape element, but also in lower altitudes be-

low 3000 m. In this altitude belt, freeze-thaw processes are not sufficient to explain the necessary debris production for the development for talus accumulations of the scale occurring in the research area. Moreover, water is a limiting factor for frost-weathering processes in the arid to semiarid valley floors with annual precipitation amounts of 150 – 300 mm at the valley floors. Glacially-induced talus cones can be especially seen in confluence positions, where tributary glaciers joined the main valleys. Moreover, the formation of talus accumulations has resulted at some locations of direct undercutting processes of the parent rock by the former glaciation. In the upper valley courses, talus cone formation can be triggered by the resedimentation of slope moraines, which cover the valley flanks up to several hundred metres above the valley floor such as in the Relincho valley at the Aconcagua-E-Side. These paraglacial landforms are similar in shape to pure slope accumulations and can be easily mistaken for weathering landforms. In the whole, the distribution of talus cones is rather independent from the climatic-controlled altitudinal zonation of geomorphological landforms.

Abele (1981) has reinterpreted landforms in the Chilean Andes, which have been formerly considered as glacial landforms by other authors, as deposits of mass movements. And indeed, these landforms might represent large-scaled rock slides. However, in the framework of the paraglacial concept they have been induced by the former glaciation and are therefore part of the paraglacial landscape cycle.

The concept of this glacial-history based origin of talus accumulation has been originally investigated by the author in the subtropical mountain ranges of the Karakoram as well in the Hindukush and Himalayas (Iturrizaga 1999a & 1999b, 2008a & 2008b), in which paraglacial landscape processes dominated by far over primary weathering processes in regard to evolution of the debris landscape. The Karakoram shows similar recent climatic and topographic conditions as well as in parts an analogous situation of the Pleistocene glaciation as in the Aconcagua massif and can serve as comparative geographic region.

References

Abele, G (1981): Trockene Massenbewegungen, Schlammströme und rasche Abflüsse. Dominante morphologische Formen in den chilenischen Anden. Mainzer Geographische Studien, Heft 23, 102 pp.

Brüggen, J (1929) Zur Glazialgeologie der chilenischen Anden. In: Geologische Rundschau 20, 1-35, Berlin.

Espizúa, L.E. (1993) Quaternary glaciations in the Rio Mendoza valley, Argentine Andes. In: Quaternary Research, volume 40, 150-162.

Iturrizaga, L (1999a) Die Schuttkörper in Hochasien - Eine geomorphologische Bestandsaufnahme und Typologie postglazialer Hochgebirgsschuttkörper im Hindukusch, Karakorum und Himalaya. In: Göttinger Geographische Abhandlungen, Band 106, 326 pp.

Iturrizaga, L (1999b) Typical debris accumulation forms and formations in High Asia. A glacial-history-based concept of the origin of Postglacial debris accumulation landscapes in subtropical high mountains with selected examples from the Hindu Kush, the Karakoram and the Himalayas. In: GeoJournal, Tibet and High Asia V, vol. 47, 277-339.

Iturrizaga, L (2008a) Paraglacial landforms in the Karakoram Mountains (Pakistan). In: Geomorphology, 95, Issues 1-2, 27-47.

Iturrizaga, L (2008b) Paraglacial landscape transformation in the Andes of Mendoza: Talus cones and scree slopes as glacially-controlled landforms. Fourth EGU Alexander von Humboldt International Conference, The Andes: Challenge for Geosciences, Santiago de Chile, November 24-28, 2008, Abstract volume, 69-70.

Kuhle, M (1985) Spuren der hocheiszeitlichen Gletscherbedeckung. In: Zentralblatt für Geologie und Paläontologie. Teil 1. Garleff, K. & H. Stingl (Ed..) Südamerika. Geomorphologie und Paläoökologie des jüngeren Quartärs, 1635-1646.

Late Paleozoic wildfires in the South American part of the Gondwana Realm

Jasper A 1,2, Uhl D 3, Machado NTG 1, Gonçalves CV 1, Guerra-Sommer M 2, Cazzulo-Klepzig M 2

1 Centro Universitário UNIVATES, Lajeado, Rio Grande do Sul, Brazil, ajasper@univates.br
2 Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Brazil
3 Senckenberg Forschungsinstitut und Naturmuseum Frankfurt, Frankfurt a. Main, Germany

For the North Hemisphere, the records of palaeowildfires from the Late Paleozoic have repeatedly been reported and studied in detail. However, palaeowildfire reports from the same age coming from the South Hemisphere, or Gondwana Realm, are relatively rare and mainly restricted to geochemical and petrological analyses. The first records of charcoal as a direct palaeobotanical evidence of palaeowildfires coming from the Gondwana were studied by Glasspool (2000) based on material from the Late Permian of the Sydney Basin, Australia. In contrast, for the South American part of the Gondwana Realm, only the mere presence of pyrogenic coal macerals has been reported by authors as Silva and Kalkreuth (2005), Kalkreuth et al. (2006) and Jasper et al. (2006). A first detailed anatomical analysis of Late Paleozoic charcoal originating from these area has been published by Jasper et al. (2008) based on material collected at the Quitéria Outcrop, Rio Bonito Formation, Paraná Basin, located in the central-eastern portion of the Rio Grande do Sul State, Brazil. In this study the authors identified three anatomical types of wood preserved as charcoal and assigned these wood types to gymnosperms and lycopsids. The material has been collected from different facies on the Quitéria Outcrop and ranged from parautochtonous to allochtonous origin, indicating that, in this area, different vegetation types,

coming from different habitats, like wet lowlands or dry hinterlands, were affected by palaeowildfires during the Early Permian in this region. On the other hand, more recent field trips have allowed to us collect material from the coal bearing strata of the Faxinal Coalfield and especially the Morro Papaléo Outcrop, both located at the central-eastern portion of the Rio Grande do Sul State, Brazil, and associated with the Rio Bonito Formation, Paraná Basin. This material was identified as charcoal and its good preservation will allow to get information about anatomical details of the source-plants and consequently of the vegetation from which these originated. For the Faxinal Coalfield, Guerra-Sommer et al. (2008) indicated a radiometric zircon age of 285.4 ± 8.6 Ma (IDTIMS U-Pb) for the tonstein layer interbedded between coal seams, locating it in the Sakmarian. After that, maybe the other Outcrops (Morro Papaléo and Quitéria), must be revised regarding their ages. With the new charcoal data from the Early Permian of the South American part of the Gondwana Realm, it will be possible to indicate whether wildfires have been more frequent as previously supposed in this area during the Late Paleozoic and whether different terrestrial ecosystems of the coal forming system from the Gondwana have been exposed to this kind of event/disturbance.

References:

Glasspool IJ (2000) A major fire event recorded in the mesofossils and petrology of the Late Permian, Lower Whybrow coal seam, Sydney Basin, Australia. Palaeo 3 164: 373-396.

Guerra-Sommer M, Cazzulo-Klepzig M, Menegat R, Formoso MLL, Basei MAS, Barboza EG, Simas MW (2008) Geochronological data from the Faxinal coal succession, southern Parana´ Basin, Brazil: A preliminary approach combining radiometric U-Pb dating and palynostratigraphy. Jour South Am Earth Sci 25: 246-256.

Jasper A, Menegat R, Guerra-Sommer M, Cazzulo-Klepzig M, Souza PA (2006) Depositional cyclicity and paleoecological variability in an outcrop of Rio Bonito Formation, Early Permian, Paraná Basin, Rio Grande do Sul, Brazil. Jour South Am Earth Sci 21: 276-293.

Jasper A, Uhl D, Guerra-Sommer M, Mosbrugger V (2008) Palaeobotanical evidence of wildfires in the Late Palaeozoic of South America - Early Permian, Rio Bonito Formation, Paraná Basin, Rio Grande do Sul, Brazil. Jour South Am Earth Sci 26: 435-444.

Kalkreuth W, Holz M, Machado G, Mexias A, Silva MB, Willert J, Finkelman R, Burger H (2006) Petrology and chemistry of Permian coals from the Paraná Basin 1: Santa Terezinha, Leão Butiá and Candiota Coalfields, Rio Grande do Sul, Brazil. Int Jour Coal Geol 68: 79-116.

Silva MB, Kalkreuth W (2005) Petrological and geochemical characterization of Candiota coal seams, Brazil – implication for coal facies interpretation and coal rank. Int Jour Coal Geol 64: 217-238.

Titel Magnetotelluric image of the South Chilean subduction zone

Kapinos G 1, Montahaei M 2, Brasse H 1

1 Freie Universität Berlin, Fachrichtung Geophysik, Malteserstr. 74-100, 12249 Berlin, Germany, kapinosg@geophysik.fu-berlin.de

2 University of Tehran, Institute of Geophysics, Iran

Fluids are a controlling factor in the subduction and rupture process and their interaction with deep-reaching fault zones in the forearc could be detectable by the magnetotelluric method (MT) since there is a large contrast in electrical conductivity between fluid and surrounding material. In order to image the conductivity distribution of the South Chilean Margin, MT deep sounding investigations (with an amphibious component) were carried out between 2000 and 2005 in the Southern Chilean Andes. The long-period MT observations along several profiles running perpendicularly to the trench and the volcanic arc from the incoming plate to the Argentinian border yield a consistent and complementary view of the South Chilean subduction zone. The isotropic modelling revealed several crustal conductive anomalies in the backarc as well as in the forearc. While the first can be associated with magma deposits beneath the present volcanic arc or with Quaternary volcanism, the conductors in the forearc are unlikely to originate from partial melts. Dehydration processes are seen here as the main cause of elevated conductivities. Data of a small network of sites – established around Llaima and Villarrica volcanoes – indicate a magmatic body at mid-crustal level beneath Villarrica, but not Llaima volcano.

Another finding is based upon the anomalous behavior of the geomagnetic induction vectors, which display a unique pattern and point consistently NE along the whole study area instead of the expected E direction due to the presence of the highly conducting Pacific Ocean. Attempts to model this behavior with simple and geologically realistic 3-D models failed, but a reasonable data fit has been obtained by employing 2-D models with a structural anisotropic in the lower crust. This anisotropy hints at a deeply fractured, fluid-rich crust with a major strike direction of 40° – 50° (SW–NE), oblique to the continental margin and in accordance with the regional stress field in the region of the volcanic arc. A surprising result is that the anisotropy persists in the forearc and may even reach the continental slope near the trench. The anisotropy direction corresponds approximately with the distribution of minor eruptive centres, parasitic vents and flank craters and can be related to the direction of maximum horizontal stress in the arc region. It is supposed that the orientation of the minor eruptive centres is the surface expression of feeder dikes built by ascending magma in the fractured crust, in accordance with the model of López-Escobar et al. (1996).

Volcano reconstruction and erosion rate calculation on stratovolcanoes and ignimbrite surfaces in the Central Andes

Karátson D 1 2, Telbisz T 1, Wörner G 2

1 Eötvös University, Dept. of Physical Geography, Budapest, Hungary
2 GZG, Abteilung Geochemie, Universität Göttingen, Germany

In this study, erosion of active and extinct (Holocene to Miocene) stratovolcanoes (18-24° S, 70-67° W) and various-aged (22-2 Ma old) ignimbrite surfaces (16-20° S, 72-69° W) of the Western Cordilleras of the Central Andes in selected areas of Peru-Chile-Bolivia-Argentina have been studied by quantitative DEM analysis.

Since the Late Oligocene, a major part of the Western Cordilleras, particularly that of lower altitude, has remained largely unchanged or was only slightly modified by

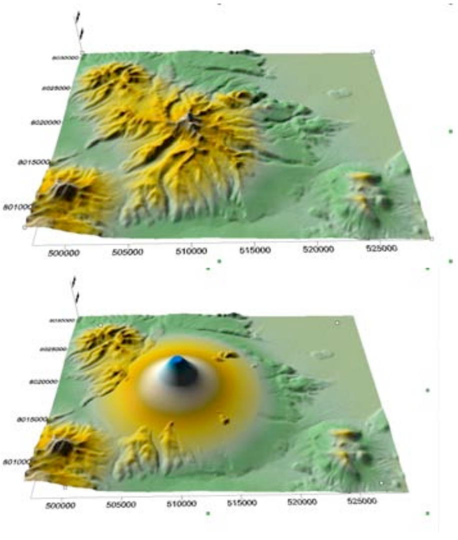


Fig. 1: shaded and coloured present relief (above) and DEM-based reconstruction using best-fitting-cone (below) of Cerro Analajsi volcano, Bolivia

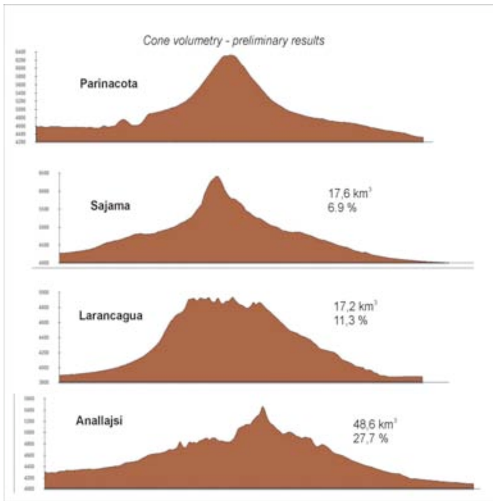


Fig. 2: Eroded volumes and percentage of total (original) volumes for selected stratocones in North Chile - Bolivia

erosion (e.g. Wörner et al., 2002; Dunai et al., 2005). This insignificant erosional modification is partly due to low erosion rates (cf. Horton, 1999, Kober et al., 2003, 2007), controlled by semiarid to hyperarid climates since the Oligocene (e. g. Hartley, 2003). However, erosion of higher volcanoes was also controlled by sporadic glaciation. The effect of glacial resculpturing is highly determined by the initial base level of the volcanic edifices, this in turn being also affected by an uneven time-space uplift since the Late Oligocene (e. g. Allmendinger et al., 1997, Lamb and Davis, 2003).

To quantify erosion processes, we started from the present surface using the SRTM data base (90x90 m resolution). We created various derivative maps including slope,

ridge and aspect maps, in order to see how erosion operates with time and what kinds of erosion pattern result. Style and pattern of erosion of Central Andean stratovolcanoes strongly depend on climate, elevation and latitudinal position. Development of valley was enhanced by episodic glaciations and has played a key role in the typical evolutionary scheme of stratocones. In addition, the location wirh respect to one of deep, major canyons on the western flank of the Andean slope (Thouret et al., 2007) was also important in some examples. We distinguished (1) crater-topped active volcano (e.g. Parinacota), (2) cone-shaped volcano with initial planezes (2a) without crater (e.g. Sajama) or (2b) with enlarged erosion crater/caldera (e.g. Cerro Mamuta; depending on the presence or absence of glaciation), (3) remnant cone with well-developed planezes at the periphery (e.g. C. Larancagua), and (4) a final "valley-stage" (e.g. C. Analajsi) where headward erosion of large valleys result in a completely degraded, lowered summit.

These stages can be successfully quantified by morphometric variables such as ridge pattern, surface roughness, circularity of various sectors of cone, cone shape ratios, etc. Original cones (Fig. 1) can be reliably reconstructed by using best-fitting cone surface and planeze remnants (that can survive in the long term especially under arid climates). Infilling the valleys of stratocone and fitting the original cone to the present surface help to calculate original volumes. Preliminary calculations for selected stratocones are shown in Fig. 2. By using age constraints, erosion rates of stratovolcanoes can also be calculated. In addition, when calibrated to dated volcanic edifices, the quantification of erosion patterns can be used as a tool for geomorphological dating.

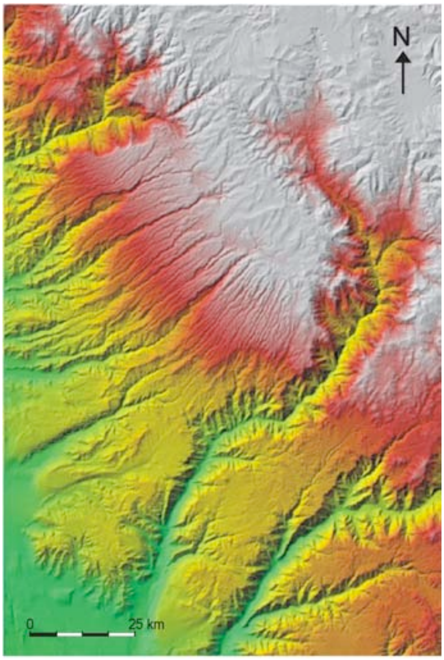


Fig. 3. Coloured and shaded relief image of the 22-24 Ma Nazca ignimbrite (S Peru). Old (Oligocene) parallel-pattern drainage, developed on the ignimbrite surface, has become inactive and cut by large canyons (quebradas).

Evolutionary history of the marine latitudinal diversity gradient along the Pacific coast of South America

Kiel S, Nielsen SN

Institut für Geowissenschaften, Christian-Albrechts-Universität, Ludewig-Meyn-Str. 10, 24118 Kiel, Germany, kiels@si.edu

Latitudinal diversity gradients with high diversity in the tropics and decreasing diversity towards the poles are the most striking biotic pattern found along many continental margins. The main causes considered responsible for this gradient are temperature, habitat diversity, and historical processes, of which the latter is the least studied. The present study explores the evolutionary history of the diversity gradient along the Pacific coast of South America from the Early Miocene onwards. Of particular interest is an unusual feature of the present-day gradient: it shows a marked increase in marine biodiversity from 42°S southward (Valdovinos et al. 2003). Basis for the present study is an extensive collection of Miocene to Pleistocene molluscan fossils from south-central Chile, in addition to literature data from Peru and Ecuador. Preliminary results show no evidence for this unusual feature in the Early Miocene, suggesting that more recent event(s) lead to this increase in southern diversity.

Reference

Valdovinos C, Navarrette SA, Marquet PA (2003) Mollusk species diversity in the Southeastern Pacific: why are there more species towards the pole? Ecography 26: 139-144.

Anomalies in the variations of the radon concentration related to geodynamical processes in the volcano Popocatepetl, Mexico

Kotsarenko A 1, Grimalsky V 2, Villegas Cerón RA 3, Koshevaya S 2, Yutsis V 3, Pérez Enríquez R 1, López Cruz-Abeyro JA 1 and Valdés-Gonzáles C 4

1 Centro de Geociencias en Juriquilla, Universidad Nacional Autónoma de México (UNAM), Apdo Postal 1-742, Queretaro, Mexico, C.P. 76001, kotsarenko@geociencias.unam.mx,

2 Universidad Autónoma del Estado de Morelos (UAEM), Cuernavaca 62210, Morelos, México.

3 Universidad Autónoma de Nuevo León (UANL), Facultad de Ciencias de la Tierra, Carretera a Cerro Prieto Km. 8, Linares, Nuevo León, México.

4 Instituto de Geofísica, Universidad Nacional Autónoma de México (UNAM), Circuito de la Inv. Científica s/n, Ciudad Universitaria, México D.F., México.

Analysis of the variation of the concentration of radon (noble gas with natural radioactivity) measured in the area of the volcano Popocatepetl is presented. Permanent observations were performed at different places (Tlamacas station, Paso de Cortes, and the referent site in Amecameca) during December 2007 - January 2009, data were collected by identical Radon Scout instruments (manufactured by SARAD company) with integration time 1 hour per sample.

Our analysis reveals certain stable tendencies. First of all, averaged values of the radon concentration observed in the volcano sites (Tlamacas and Paso de Cortes) are 4-10 greater of those measured in the Amecameca referent site. Then, there is a distinct difference between the data recorded at 2 volcano sites. Paso de Cortes (20 km away from volcano) data regularly manifest high level values with only diurnal variation, unlike the Tlamacas station (4 km away) data display considerable variations possibly associated with volcano geodynamics. Thus, there are numerous gradual depletions of the radon concentration with duration from about 12 hours up to several days. We associate most of observed anomalies with 2 volcano-related events: 1) in major cases radon depletions anticipates moderate volcano eruptions, and 2) some of the observed anomalies accompany tectono-volcanic events.

Paleobathymetric changes and paleoenvironmental turnover across the Cretaceous-Paleogene in Brazil

Koutsoukos Eduardo AM

1 Geologie-Paläontologie Institut für Geowissenschaften, Universität Heidelberg, Im Neuenheimer Feld 234, DE-69120 Heidelberg

2 PETROBRAS-CENPES, Cidade Universitária, Ilha do Fundão, 21941-915 Rio de Janeiro, RJ, Brazil: ekoutsoukos@gmail.com

Studies developed along the past three decades in more than 200 localities worldwide, where the Cretaceous-Paleogene (K/Pg) boundary is recorded in both onshore and offshore sites, have allowed for a detailed reconstruction of the sequence of stratigraphic and paleobiotic events across the boundary transition, making this the best documented ever in the published geoscience literature.

The Poty section, near Recife, in the Pernambuco-Paraíba, NE Brazil, is presently the most important marine outcrop section of the K/Pg boundary in low-latitude regions South of the Equator. At this section the boundary is marked after the top of alternating deposits of carbonate mudstones and marlstones of the Gramame Formation (Plummerita hantkeninoides Zone; uppermost Maastrichtian), which yield a well-diversified benthic foraminiferal assemblage typical of upper bathyal and deep neritic environments, such as: Cibicides hedbergi, Coryphostoma midwayensis, Fursenkoina sp., Gavelinella stephensoni, Guttulina ad-

haerens, Neoflabelina ex gr. pilulifera, N. rugosa, Nonionella cretacea, Orthokarstenia clarki, O. parva, O. whitei, Nuttallides truempyi, Pyramidina rudita,, Siphogenerinoides bramlettei, Vaginulinopsis midwayana, Valvulineria amarali, Gaudryina laevigata, G. pyramidata and Dorothia bulleta. Overlying lower Paleocene deposits of wackestones and carbonate mudstones of the Marinha Farinha Formation (Zones Pα, P1 and P2; Danian), yield middle-deep neritic benthic foraminiferal assemblages characteristic of the "Midway-type" microfauna (cf. Berggren & Aubert, 1975), such as Allomorphina paleocenica, Nonionella ovata, N. soldadoensis, Tappanina selmensis, Loxostomoides plummerae, Pulsiphonina prima, Anomalinoides acuta, A. capitata, A. praeacuta, Valvulineria scrobiculata, Alabamina midwayensis, Gavelinella coonensis and Cibicidoides alleni.

The K/Pg boundary has also been recorded offshore Campos Basin, in southern Brazil, at a continuous cored section. Deposits of the upper Maastrichtian yield a "flysch-type"/Rhabdammina microfauna of the middle bathyal, with Anomalinoides aragonensis, Gavelinella beccariiformis, G. dayi, Pullenia bulloides, Ammodiscus cretacea, A. glabratus, Cribrostomoides trinitatensis, Gaudryina pyramidata, Hormosinella trinitatensis, Recurvoides sp., Reophax globosus, Repmanina charoides corona, Bathysiphon sp. and Rhizammina indivisa, among others. Immediately overlying deposits of the Danian (Zone Pα) yield a transitional "Velasco/Midway-type" microfauna of the upper bathyal, such as Anomalinoides alazanensis, A. chiranus, Bolivina midwayensis, Gyroidina bandyi, Gyroidinoides dissimilis, G. girardianus, Hoeglundina sp., Osangularia plummerae, O. velascoensis, Clavulinoides plummerae, Arenobulimina sp., with subordinate amounts of nodosariids and vaginulinids, among others.

The stratigraphic and micropaleontological record of these sections present evidence of a significant sea-level fall, probably in the order of magnitude of between 100 and 300m. A sea-level fall of similar magnitude was also inferred for the K/Pg boundary stratotype section at El Kef, in northern Tunisia (Speijer & Van der Zwaan, 1994, 1996), from an upper bathyal in the latest Maastrichtian to middle-deep neritic settings in the early Danian. In deeper water sites (deposited in middle bathyal and deeper), such as at El Mulato, NE Mexico (Alegret et al., 2002), Agost, SE Spain (Alegret et al., 2003), Blake Nose Plateau, western North Atlantic (Alegret & Thomas, 2004) and in the Walvis Ridge, eastern South Atlantic (Alegret & Thomas, 2007), the benthic foraminiferal assemblages recorded across the boundary transition do not show any marked extinction and environmental change. However, there are noticeable minor community shifts represented by varying trophic strategies (from foraminiferal assemblages dominated by infaunal morphogroups in the latest Maastrichtian to assemblages dominated by epifaunal or even mixed morphogroups in the early Danian), which could be chiefly related to severely disrupted primary productivity (e.g., Alegret et al., 2002, 2003; Alegret & Thomas, 2004, 2007) and reduced carbon flux (food supply) to the deep-sea benthos in the aftermath of the boundary event.

References

Alegret L, Thomas E (2004) Benthic foraminifera and environmental turnover across the Cretaceous/Paleogene boundary at Blake Nose (ODP Hole 1049C, Northwestern Atlantic). Palaeog, Palaeoc, Palaeoec 208 (1-2): 59-83

Alegret L, Thomas E (2007) Deep-Sea environments across the Cretaceous/Paleogene boundary n the eastern South Atlantic Ocean (ODP Leg 208, Walvis Ridge). Mar Micropal 64: 1–17.

Alegret L, Arenillas I, Arz J A, Liesa C, Meléndez A, Molina E, Soria A R, Thomas E (2002) The Cretaceous / Tertiary boundary: sedimentology and micropalaeontology at El Mulato section, NE Mexico. Terra Nova 14: 330–336

Alegret L, Molina E, Thomas E (2003) Benthic foraminiferal turnover across the Cretaceous/Paleogene boundary at Agost (southeastern Spain): paleoenvironmental inference. Mar Micropal 48: 251-279.

Berggren W A, Aubert J (1975) Paleocene benthonic foraminiferal biostratigraphy, paleobiogeography and paleoecology of Atlantic-Tethyan regions: Midway-type fauna, Palaeog, Palaeocl, Palaeoec 18: 73-192.

Speijer R P, Van der Zwaan G J (1994) Extinction and recovery patterns in benthic foraminiferal paleocommunities across the Cretaceous/Paleogene and Paleocene/Eocene boundaries. Geol Ultraiectina 124:19-64.

Speijer R P, Van der Zwaan G J (1996) Extinction and survivorship of southern Tethyan benthic foraminifera across the Cretaceous/Palaeogene boundary. In: Hart M B (editor) Biotic Recovery from Mass Extinction Events. Geol Soc, Spec Publl 102: 343-371.

Age and P-T metamorphic conditions of the migmatitic basement of the Northwestern Sierras Pampeanas, Argentina.

Larrovere M 1, Toselli A 1, Rossi J 1, de los Hoyos C 1, Basei M 2, Belmar M 3

1 INSUGEO – CONICET, Tucumán, Argentina, marianlarro@yahoo.com.ar
2 Centro de Pesquisas Geocronológicas, Universidade de Sao Paulo, Brasil
3 Departamento de Geología, Universidad de Chile

Migmatitic rocks are widely distributed in the northwest and centre of Argentina and most of them belong to the Sierras Pampeanas metamorphic basement. This basement was generated during the evolution of two superposed orogenic cycles (Aceñolaza and Toselli, 1976; Aceñolaza et al., 2000): the Pampean (Late Precambrian – Lower Cambrian) and the Famatinian (Upper Cambrian – Devonian). These oregenies have been interpreted as the product of subduction and continental collision of several terranes along the margin of Gondwana (e.g. Ramos et al, 1986; Ramos, 1988; Kraemer et al., 1995; Rapela et al, 1998, 2001) or as contiguous stages in the evolution of an intra-cratonic mobile belt along the margin of Gond-

wana (Lucassen et al., 2000), this last interpretation mainly in the northwest of Argentina. In the study area, localized between the ranges of Ancasti, Ambato y Aconquija in the Northwestern Sierras Pampeanas, three new main lithostratigraphic units were defined: El Portezuelo Metamorphic-igneous Complex (EPMIC), La Chilca Shear Zone (LChSZ) and Quebrada del Molle Metamorphic Complex (QMMC). The EPMIC includes the greatest part of the study area and it is composed mainly of migmatites. The migmatites are mostly metatexites of stromatitic type but also diatexites has been recognized, defining a regional migmatitic belt in N-S direction. The migmatites have lithologic continuity with gneisses, schists, calcsilicates and marbles, this assembly define the EPMIC. Concordant syntectonic tonalites complete this unit. Both rocks, of the lowest metamorphic grade (schists) and the highest metamorphic grade (migmatites) are considered from the same continental crust block but developed in different structural levels. The migmatites contain the mineral assemblage Qtz-Pl-Bt-(±Kfs)-(±Sil)-(±Grt)-(±Crd). This mineralogy is consistent with amphibolite to granulite metamorphic facies conditions. A regional S2 foliation is present in the migmatites with a NNW-SSE /N-S strike and ENE/E dip. To determine P-T conditions of the metamorphism (M2) that produced the widespread anatexis of metasedimentary rocks of the EPMIC four samples of migmatite leucosomas were selected. Temperatures and pressures were calculated using analysis from minerals (garnet, biotite, plagioclase and cordierite) in contact with each other. Multiphase equilibria method was applied using the software TWQ 2.32. For the thermal peak, we estimated P-T conditions of 760 ºC and 5-6 kbar on core analysis for the sample 7649 (diameter of garnet > 1 mm). Lower P-T conditions of 630-670 ºC and 4-5 kbar were estimated in samples 7295 and 7621 with garnets of diameters < 1 mm affected probably by diffusion process during the cooling. A highest pressure close to 9 kbar (T of 670 ºC) was estimated for the sample 7444. P-T conditions of retrograde metamorphism were calculated using mineral rim compositions. The results obtained were 650 ºC and 4 kbar for the sample 7649, 630 ºC and 5 kbar for the sample 7295, 615 ºC and 4 kbar for the sample 7621, and 640 ºC and 5 kbar for the sample 7444. Geothermobarometric results of core and rim analysis allowed deducing two types of post peak P-T paths: isobaric cooling paths with P/T gradients of 0.51 kbar/100 ºC and 0.91 kbar/100 ºC, and a strong isotermic decompression path with a P/T gradient of 14.88 kbar/100 ºC. The differents P-T paths observed could be interpreted as a consequence of differential movements of the crust, where a strong isotermic decompression path occur possibly related to the orogenic front. In addition to this, the isobaric cooling paths were related to internal areas of the orogen or the retro-arc associated to thermal sources. To constrain the timing of metamorphism, monazites from trhee different migmatite leucosomes from the El Portezuelo Metamorphic-igneous Complex (EPMIC) were dated by using single mineral U-Pb geochronology. Monazite analysis yield a mean 206Pb/238U age of 471.3 ± 1.3 Ma using three monazite fractions from the sample 7444-leu, a mean 206Pb/238U age of 476.7 ± 5.0 Ma from the sample 7550-

leu (two monazite fractions), and a mean 206Pb/238U age of 470 ± 12 Ma from the sample 7649-leu (trhee monazite fractions). These results are interpreted as the timing of peak metamorphism. In conclusion, the migmatites from the basement of Northwestern Sierras Pampeanas evolved in amphibolite to granulite facies conditions with medium to high pressures (4 to 9 kbar) and high temperatures (630 to 760 ºC) as a consequence of a progresive regional metamorphism (M2) that was product of an convergent orogenic event during the Early Ordovician. Even though the origin of migmatites of the EPMIC respond to a convergent orogenic model and they could be relationed to additional thermal sources that allowed to reach the peak metamorphic temperatures. Differential movements of the crust determined high exhumation rates relationed to the orogenic front. However, there is not any clear evidence of this decompression in the migmatites of internal areas of the orogen. The metamorphism of the EPMIC was part of the Famatinian Orogeny developed on the Gondwana proto-pacific margin during the Early Ordovician. Because of this, it could be relationed towards the north with rocks of high metamorphic degree of the Sierra de Quilmes (≈ 470 Ma; Büttner et al., 2005), and towards the east with the metamorphic basement of Sierra de Ancasti (El Portezuelo Formation, 472 ± 26 Ma; Knüver, 1983). Furthermore it has continuity to the south with the rocks of high metamorphic degree of the Sierra de San Luis (Nogolí Metamorphic Complex, ≈ 478 Ma; Steenken et al., 2006) and towards the south-west with the migmatites of the Sierra de Valle Fértil (466 Ma; Rapela et al., 2001). This previous data and the new geochronological results presented here put in evidence the importance and magnitude of the Famatinian metamorphism in the evolution of metamorphic basement of Sierras Pampeanas during the Early Palaeozoic times.

References

Aceñolaza F, Toselli A (1976) Consideraciones estratigráficas y tectónicas sobre el paleozoico inferior del noroeste argentino. Actas del segundo Congreso Latinoamericano de Geología Caracas 755-763

Aceñolaza F, Miller H, Toselli A (2000) The Pampean and Famatinian Cycles - Superposed Orogenic Events in West Gondwana In: Miller H and Herve F (Eds): Geoscientific Cooperation with Latin America. Z Angew Geol SH 1: 337-344

Buttner S, Glodny J, Lucassen F, Wemmer K, Erdmann S, Handler R, Franz G (2005) Ordovician metamorphism and plutonism in the Sierra de Quilmes metamorphic complex: Implications for the tectonic setting of the Northern Sierras Pampeanas (NW Argentina). Lithos 83: 143-181

Knüver M (1983) Dataciones radimétricas de rocas plutónicas y metamórficas. En: Aceñolaza F, Miller H. Toselli A (Eds): La Geología de la Sierra de Ancasti. Münstersche Forschungen Geol Paläontol 59: 201-218.

Kraemer P, Escayola M, Martino R (1995) Hipótesis sobre la evolución tectónica neoproterozoica de las Sierras Pampeanas de Córdoba (30°40' - 32°40' S) Argentina. Rev Asoc Geo. Argentina 50: 47-59

Lucassen F, Becchio R, Wilke H, Thirlwall M, Viramonte J, Franz G, Wemmer K (2000) Proterozoic–Paleozoic development of the basement of the Central Andes (18-26º)-a mobile belt of the South American craton. J South Am Earth Sci 13: 697-715

Ramos V (1988) Late Proterozoic - Early Paleozoic of South America: a collisional history. Episodes 11: 168-174

Ramos V, Jordan T, Allmendinger R, Mpodozis C, Kay S, Cortés J, Palma M (1986) Paleozoic terranes of the central Argentine Chilean Andes. Tectonics 5: 855-880

Rapela C, Pankhurst R, Casquet C, Baldo E, Saavedra J, Galindo C (1998) Early evolution of the proto-Andean margin of South America. Geology 26(8): 707-710

Rapela C, Casquet C, Baldo E, Dahlquist J, Pankhurst R, Galindo C, Saavedra J (2001) Las Orogénesis del Paleozoico Inferior en el margen proto - andino de América del Sur Sierras Pampeanas Argentina. J Iberian Geology 27: 23-41

Steenken A, Siegesmund S, Lopez de Luchi M, Frei R, Wemmer K (2006) Neoproterozoic to Early Palaeozoic events in the Sierra de San Luis: implications for the Famatinian geodymamics in the Eastern Sierras Pampeanas (Argentina). J Geol Soc London 163: 965-982.

First experience with a National GIS on Georisks in Guatemala

León X 1, Bautista M 2, Strauch W 2

1 INSIVUMEH (Instituto Nacional de Sismología, Vulcanología, Meteorología e Hidrología), Guatemala, email: xiomaraleon@gmail.com

2 Bundesanstalt für Geowissenschaften und Rohstoffe (BGR, Germany), Project on the Mitigation of Georisks in Central America, Managua, Nicaragua

INSIVUMEH (Instituto Nacional de Sismología, Vulcanología, Meteorología e Hidrología), the principal governmental geosciences institution in Guatemala, has established a National GIS on Georisks. The institution is responsible for the development and maintenance of monitoring and early warning networks in the country, for hazard and risk assessments, is a major player in the activities of the National Coordinator for Disaster Reduction (CONRED) and cooperates also with other national or international institutions in basic or applied research projects.

In the last decade, many projects were carried out in Guatemala on hazard assessment, vulnerability risk evaluation or on general geological and hydrometeorological topics. The resulting data were archived rather disperse in many institutions, universities, NGO´s or by individual researchers. Access to these data for further works was frequently difficult. Even in INSIVUMEH itself, data sharing was not always accomplished in an optimal way between the different scientists and departments. Sometimes, important data were not handy in case of an emer-

gency. There was also an imminent danger of data loss as data archiving was not always organized properly.

Thus, INSIVUMEH decided to establish a centralized Geographic Information System (GIS) on Georisks which should assure the proper use of the data by earth scientists and emergency managers. The GIS is developed in cooperation with BGR/Germany as part of the Project on the Mitigation of Georisks in Central America making use of the experience gained by cooperating national geosciences institutions in other Central American countries, especially in Nicaragua (Instituto Nicaragüense de Estudios Territoriales, INETER) and El Salvador (Servicio Nacional de Estudios Territoriales, SNET).

Data were obtained from the archives of INSIVUMEH itself, and from data sets existing in other institutions (MAGA, Ministry of Agriculture and Food, CONRED), universities (Universidad del Valle, Universidad de San Carlos de Guatemala), the National Statistics Institute (INE), the National Geographic Institute (IGN), and international institutions (e.g. COSUDE, NORSAR, NGI, USGS).

Existent important data sets cover: National basic cartography, digital elevation models (DEM), air photos and satellite imagery covering most of Guatemala, seismicity of Guatemala and Central America, geology, seismic hazard, volcano hazard, landslide susceptibility, drought hazard, hydrological atlas, climate atlas, and other documents related with some kind of hazard.

The data base is divided in two parts: 1) the repository in their original form (according the original projects) of much of the GIS coverage elaborated by the permanent monitoring programs and temporary projects executed in the country; 2) a GIS data base in ArcGIS format (shape files or geodatabase) of the most important, or most frequently used data, well organized according thematic considerations. The data base is installed in a central server accessible via LAN by all scientific departments of INSIVUMEH. Copies of the data can be obtained by national and international users contacting the institution. It is planned to install a mirror of parts of the data base at CONRED for the use in rescue and disaster prevention activities.

The Web site of INSIVUMEH (www.insivumeh.gob.gt) is recently undergoing a major upgrade and will contain a section of the GIS data base, maps, and access to the meta data of the data base. Interactive maps will be published using map servers.

Though the GIS is still in its initial phase it was already used, recently, to design new seismic and meteorological station networks and to establish sites for meteorological radars. Landslide susceptibility maps were developed indicating the location of landslide events having occurred in the country.

The Palynologic and Stratigraphic Characterization of the Alluvial Depositis, Campo do Ciama, São Bonifácio Municipality, Santa Catarina, Brazil

Lima G L 1, Oliveira MAT 2, Bauermann SG 3

1 Federal University of Santa Catarina, Center of Philosophy and Human Sciences, Department of Geosciences, Program Post Graduate in Geography. Florianópolis, SC, Brazil, gislelima99@gmail.com

2 Federal University of Santa Catarina, Center of Philosophy and Human Sciences, Department of Geosciences, Laboratory of Geodynamics Superficial. Florianópolis, SC

3 University Lutheran of Brazil, Palynology Laboratory. Canoas, RS, Brazil

The palynologic analysis associated to the isotopic analysis of carbon, to the sedimentology, and to the stratigraphic, allows the palaeoenvironmental characterization of the alluvia-coluvional sedimentary surroundings. This piece of work presents the results of the stratigraphic and palinologic studies conducted in uprising section in Campo da Ciama towards a palaeoenvironmental characterization. The Campo do Ciama is situated in the northeast of São Bonifácio municipality in the east center of Santa Catarina State in Brazil. This area is settled over a geologic structure shaped by granitic rocks from the Suite Intrusiva Pedras Grandes (FATMA 2005). The local relief is characteristic of Serras do Leste Catarinense, geomorphologic unit in which this area is inserted (FATMA 2005). Due to the altitude (could reach 1018 meters height), Campo do Ciama clime is classified as damp mesothermic with light summer seasons (FATMA 2005). In the past, there was in the area a pine center, which was intensively exploited by the wood industry in middle of the twentieth century (Klein 1981). The rivers, which drain Campo do Ciama area, belong to the Ponche River Watershed (FATMA 2005). The stratigraphic section pointed out in this research was set up in a first order channel in one of the affluents of this river. The section has about 20 meters width and 1,90 meters height. Through the characteristics found in the field (matrix color, touch texture, structure and type of contact), nine units were individualized. The unit 1 corresponds to the weathering mantle, and over it was developed the pedologic horizons relating to the units 2 and 3. Those horizons were recovered by alluvial layers, which correspond to the units 4, 5, 6 and 7. Over those alluvial layers it was developed another pedologic horizon, referred to unit 8, which was recovered by an alluvia-coluvial layer referred to unit 9. Samples from those units were submitted to a granulometric analysis (according to Suguio 1973), an analysis of the organic matter tenor (Walkley-Black Method), an isotopic analysis, a radiometric date, and a palynologic analysis (according to Faegri and Iversen 1975). The results of the granulometric analysis provided a better differentiation between pedologic layers and horizons. The most part of the samples from the alluvial layers and alluvia coluvial were classified (according to the classification of Flemming 2000) as materials, which contain more than 50% of mud (sandy mud and light sandy mud). The horizon pedologic samples were classified as sand muddiness (less than 50%

of mud). The result of the analyses of the carbon organic tenor also contributed to this differentiation: in the pedologic horizons, the organic matter concentrations changed from 3,45 to 8,80%, and the distribution of the tenors in the units inner followed the pattern of the distribution of the organic matter in the pedologic horizons, which means, increasing in the direction of the top of the soil. In the alluvial layers and alluvia coluvial, the variation was from 2,10 to 7,90%, and the distribution along the layers did not follow a pattern, as it is a characteristic of this kind of deposit, where there is an important concentration of organic matter along the layer, but it is distributed in an unequal way. The results of the carbon isotopes (δ13 C) changed from -19,10 to -21,97, indicating the predominance of C4 plants (gramineous) in the units 1 to 6. From the unit 7, the values oscillated from -22,09 to -22,97, indicating the predominance of C3 plants (trees). Samples from units 3 (pedologic horizon) and 5 (alluvial layer, rich in organic matter) were submitted to date by the carbon 14 method and the ages obtained were around 7,2 ka B.P. Samples from all the units were submitted to a palinologic analysis, totalizing 16 samples. From those, only six were considered fertile: units 2 and 8 (correspondent to pedologic horizons), and units 5, 6 and 9 (referent to alluvial layers and alluvia coluvial). In the unit 2 there is predominance of field vegetation, with eminence to Poaceae and Asteraceae. In the units 5 and 6, the pollen grains of the field taxon are still prevail; however it is observed a significant increasing of the pollen grains of the wood taxon, with eminence to Weinmannia and Clethra. In the units 8 and 9, it was registered an important diminution of pollen grains in the field taxon and significant increasing of wood vegetation. Those results enabled the elaboration of the preliminary scenario of the palaeoenvironmental evolution to the Campo do Ciama. In a 7 ka former period, the area passed through a stable environmental phase, which allowed the arrangement of the pedologic horizons in regionally environmental dryer and thinner than the actual, suggested by the predominance of the fields. After the arrangement of those pedologic horizons, the area pass through a period of environmental instability, increasing of rainy, which resulted in the deposition of alluvial layers rich in organic matter. This increasing of humidity suggested by the stratigraphic register, was responsible by the expansion of the forest in a 7 ka former period B.P.. After this phase of environmental instability, the area pass through a new period of environmental stability, and this provided the development of other pedologic horizon. This phase is marked by the great expansion of forest.

Supported by CNPq - National Counsel of Technological and Scientific Development (PhD scholarship)

References

Faegri K, Iversen J Textbook of pollen analysis. Hafner Press New York 1975.
FATMA (Fundação de Amparo à Tecnologia e ao Meio Ambiente) Parque Estadual da Serra do Tabuleiro: Diagnóstico dos Meios Físico e Biótico – Pro-

duto Básico de Zoneamento. CD-ROM 2005.
Flemming B W A revised textural classification of gravel-free muddy sediments on the basis ternary diagrams. Continental Shelf Research n 20 pp 1125-1137 2000.
Klein R M Fisionomia, importância e recursos da vegetação do Parque Estadual da Serra do Tabuleiro. Sellowia Anais Botânicos do Herbário Barbosa Rodrigues. n 33 p. 5-55 Itajaí 1981.
Sugio K Introdução a sedimentologia. Edgard Blücher LTDA São Paulo 1973

Geology and exploration geochemistry of the El Volcán Gold Project in the Maricunga Belt, northern Chile

Lohmeier S 1, Lehmann B 1, Du A 2, Burgess R 3

1 Mineral Resources, Technical University of Clausthal, 38678 Clausthal-Zellerfeld, Germany
2 Institute for Geoanalysis, Chinese Academy of Sciences, Beijing, China
3 Department of Earth Sciences, University of Manchester, UK

The El Volcán exploration area (AndinaMinerals) is part of the Maricunga Gold Belt in northern Chile (Mpodozis et al. 1995), around 130 km to the east of the city of Copiapó at the foot of the volcano Copiapó. The 50 km² area is at 4400 up to 5300 m altitude and is explored since 2003 by surface mapping and sampling as well as core and cuttings drill programs. The current results define a low-grade gold resource of around 200 t of gold (242 Mt @ 0.85 g/t Au). Elevated copper and molybdenum contents may be recovered as by-product.

The Maricunga Belt is situated in the southern part of the Central Volcanic Zone, where normal subduction passes southwards to flat slab subduction. The basement consists of Devonian sedimentary rocks and is intruded by Late Carboniferous to Permian granitoids. Continental andesitic lavas and siliciclastic rocks form the Mesozoic unit. The Cenozoic rocks are dominated by volcanic rocks of andesitic to dacitic composition, partly covered by rhyolitic and dacitic ignimbrite blankets which evolved until 5 Ma ago. The contemporary surface is characterized by the Cenozoic volcanism, including subvolcanic stocks and widespread breccias, and NNE striking inverted mid- to late-Cretaceous and Miocene faults generated by compressional tectonics (Muntean and Einaudi 2001). The ore deposits in the Maricunga Belt are of a transitional porphyry to epithermal style with high-sulfidation gold- (silver) mineralization. The western part has mineralization with an age of 24-20 Ma (La Coipa, La Pepa, Refugio, Santa Cecilia mines), the eastern part is 14-10 Ma old and hosts the Marte, Lobo, Patanillo and probably Aldebaran mines (Vila and Sillitoe 1991), as well as the El Volcán prospect.

The major ore stages in the Volcán deposit are early porphyry-style quartz veinlets (magnetite-hematite-pyrite-molybdenite-chalcopyrite) and advanced argillic overprint in quartz-alunite-anhydrite veinlets (pyrite-enargite-tennantite/ tetra-

hedrite-covellite-gold). A remarkable feature of the system is the abundance of anhydrite (several wt% of the rock, partly weathered to gypsum) over several hundret m drill core depth, which occurs together with equally abundant alunite. The presence of deep anhydrite indicates descending acid- sulfate water from shallow steam condensation. The hydrothermal system is dated by eight molybdenum-rich bulk ore samples which define a Re-Os isochron age of 11.0 $\pm$ 0.2 Ma (2 sigma) with an initial 187Os/188Os ratio of 0.7 $\pm$ 0.2. Three Ar-Ar age data on deep potassic alteration and on alunite-altered rock give 11.4 $\pm$ 0.5 Ma (K-feldspar), 11.2 $\pm$ 0.7 Ma (alunite) and 11.1 $\pm$ 0.3 Ma (alunite). These ages overlap within error and define a combined age of 11.20 $\pm$ 0.25 Ma (2 sigma) for the hydrothermal system.

The hydrothermal system is characterized by a spectrum of elements enriched over bulk continental crust, i.e. Re (320 x), Au (190 x), Te (160 x), S (90 x), As (45 x), Mo (35 x), Se (28 x), Sb (26 x), Bi (11 x), Cu (10 x), Hg (8 x), Pb (5 x) W (5 x). Cadmium, silver, tin and zinc are slightly enriched (2-3 x). These numbers are arithmetic means derived from 2-m- drillcore intercepts on 40,000 drill meters (Au, Cu, Mo by AAS) supplemented by ICP-MS data on around 14,000 drill meters. Correlation coefficients and visual examination of XY plots define three element associations for the hydrothermal system, i.e. Au-Cu, As-S-Te-Se- Sb-Bi, and Mo-Re-W-Sn. Arsenic displays the widest geochemical halo and is the most efficient indicator element for the gold mineralization. Antimony, bismuth and selenium are related to gold mineralization as well, although with less dispersion and enrichment. Antimony, bismuth, selenium and arsenic are primarily in fahlore. Mercury mostly occurs in elevated abundance in morphological highs (close to volcano Copiapó) and in areas with advanced argillic alteration. Gold is linked to black and grey banded quartz veinlets and can be found in all parts of the drill area. The dark color of the quartz veinlets is likely due to the abundanc of vapor-rich fluid inclusions (Muntean and Einaudi 2001). Molybdenite occurs locally without any recognizable systematics. Rhenium is a substituent for molybdenum in molybdenite. There is a distinct correlation between tungsten and molybdenum. Tungsten occurs in the form of scheelite, and characterizes together with molybdenite the high-temperature core of the hydrothermal system.

References

Davidson J, Mpodozis C (1991) Regional geologic setting of epithermal gold deposits, Chile. Econ Geol 86: 1174-1186

Mpodozis C, Cornejo P, Kay SM, Tittler A. (1995) La Franja de Maricunga: síntesis de la evolución del Frente Volcánico Oligoceno-Mioceno de la zona sur de los Andes Centrales. Revista Geológica de Chile 21: 273-323

Muntean JL, Einaudi MT (2001) Porphyry-epithermal transition: Maricunga belt, northern Chile. Econ Geol 96: 743-772

Sillitoe R (1976) Andean mineralization: a model for the metallogeny of convergent plate margins. Geol Assoc Canada Spec Paper 14: 59-100

Vila T, Sillitoe RH (1991) Gold-Rich Porphyry Systems in the Maricunga Belt, Northern Chile. Econ Geol 86: 1238-1260

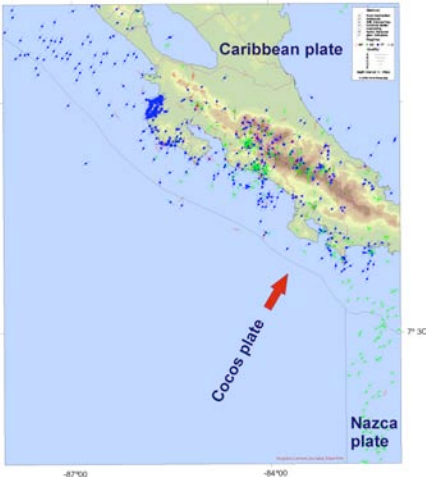
Unravelling of the modern stress field, Coulomb Stress changes and seismic risk in Costa Rica, an applied approach.

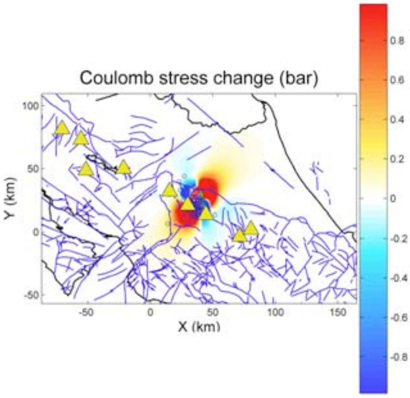
López A 1, Müller B 2, Heidbach O 2

1 I.C.E. &Universidad Latina; alopezs@ice.go.cr
2 World Stress Map team, Geophysikalisches Institut der Universität Karlsruhe

Representative Quaternary fault-slip populations, dike orientations, breakouts, alignment of Quaternary cinder cones covering 60% of Costa Rica and earthquake focal solutions are recompiled and analyzed to obtain an updated and more realistic reconstruction of the evolution and partitioning of the modern stress field in this part of the Cocos-Caribbean-Nazca plates interaction scenario. A modern Stress Map is herewith presented. In general, the trend of present day SHmax depicts an average orientation of N22°E similar to the N30°E of the convergence direction of the nearby Cocos plate which is being subducted under the Caribbean plate at the Middle America trench at a rate of 75-90 mm yr-1. This interaction constitutes the main regional ongoing deformation controlling factor. Stress partitioning is recognized at several subdomains as well as important deflections in the vicinity of the major regional structural accidents, cordilleras and tectonic blocks. At these locations the contraction is mainly N-S and N33°W, while transtension rather than pure distension is presently acting within the neovolcanic subareas. Recent clockwise SHmax rotation from NW to NE is also postulated based on the results reflecting relative Plate displacements.

For the first time is possible to detect and map subtle changes between the local and regional stress fields allowing a direct application to important research on tectonic modeling, proper design of civil Works and seismic hazard. Local stress tensor axes and magnitudes from the stress map are among the input values used to investigate the Coulomb stress changes resulting from the 08 January 2009 highly destructive Cinchona earthquake (Mw 6.2), with shallow hypocenter within a volcano edifice close to central Costa Rica where the main civil, social and public infrastructure is located. The results show that several regional thrusts faults have gained at least 0.8 bars of stresses imparted from that seismic source and interaction with neighbouring magmatic chambers is suspected at several crustal levels. Both conclusions, similar to other ones obtained at different regional neotectonic environments, indicate that seismic risk has increased as a consequence of such stress transfers. This parametric and collaborative analysis is a new application which provides new insights into the fault reactivation potential and earthquake prone destruction in this complicated triple junction setting.





Constrained 3D density model of the upper crust from gravity data interpretation for the Central Volcanic Range of Costa Rica: fluid and volatile pathways and reservoirs for the southeastern end of the Quaternary Central American Volcanic Arc.

Lücke OH 1, Götze HJ 1, Alvarado GE 2, Schmidt S 1, Fairhead D 3

1 Institut für Geowissenschaften, Abteilung Geophysik, Christian-Albrechts-Universität zu Kiel. osluecke@geophysik.uni-kiel.de
2 Instituto Costarricense de Electricidad
3 GETECH, Leeds

A 3D density model was prepared to foster better understanding of characteristics of fluid and volatile pathways and reservoirs in the upper crust as part of the subduction factory. The 3D density modeling was carried out in the geophysics department at the Institute of Geosciences of the Christian-Albrechts-University in Kiel, as part of the Collaborative Research Center (Sonderforschungsbereich 574).

The density model was constrained by seismic tomography results from the seismic/seismological group of the SFB574, as well as previously published P-wave velocity models from wide-angle refraction seismic and simplified surface geology. To further constrain the depth and geometry of gravity anomaly sources, power spectrum analysis was carried out and Euler deconvolution solutions were calculated for the gravity field. Results show the effects of Quaternary magmatism on the structure of the upper crust beneath the Central Volcanic Range of Costa Rica as well as structures related to paleomagmatic processes beneath the Miocene-Pliocene Aguacate volcanic arc.

The model also shows structures and crustal bodies related to the geometry of the basement in the back-arc region, which shows influence from extensional tectonic processes related to the continuation of the Nicaragua graben in northeastern Costa Rica.

Tracing the source of Neogene ignimbrites in the Western Andean by isotope provenance.

Mamani M, Wörner G

GZG , Abt. Geochemie, Universität Göttingen, Germany, mmirian@gwdg.de

Large volumes (400 km3 to 1300 km3) of magma were repeatedly erupted in the form of ignimbrites from centers in the Western Andean Cordillera and accumulated on the Western Andean slope between 24 to 10 Ma. Later most of these volcano centers were eroded and cover by younger volcanic products. The source regions of these magmas, i.e. Miocene ignimbrite centers are important locations for the formation of ore deposits. However, often, the locations of the source calderas are unknown.

Quaternary lavas of a broad range of SiO2 contents (54 to 78 wt%) for Quaternary volcanoes have previously been shown to carry the Pb- and Nd- isotope composition of local basement (Mamani et al., 2007, 2009). In this study we attempt to correlate Pb- and Nd-isotope ratios from ignimbrites that were sampled on the western Andean slope far from their center to the crustal domains were it was originally sourced. We do so in comparing ignimbrite isotope values to those of stratovolcanoes in the prospective source regions (Cora Cora, Sara Sara, Coropuna, Chachani, El Misti, Ubinas, Yucamane, Parinacota).

A Neogene ignimbrite layer dated at 24 Ma in the Cuno Cuno section (73°05'40"-15°58'50") within the Oligocene middle of Moq C Formation is characterized by 87Sr/86Sr =0.7086, eNd values = -2.9, TDM ages=1 Ga, and 206Pb/204Pb = 18.804. Miocene ignimbrite (14 Ma) at the base of Moq D Formation have 87Sr/86Sr =0.7078, eNd values = -2.8, TDM ages=1.4 Ga, and 206Pb/204Pb = 18.768. In the Majes section (72°26'14"-16°13'55") Miocene ignimbrites of 16 Ma (top of Moq C Formation) and 14 Ma (base of Moq D Formation) are characterized respectively by 87Sr/86Sr =0.7086 and 0.7070, eNd values = -6.9 and -5.4, TDM ages=1.15 and 1.2 Ga, and 206Pb/204Pb = 18.400 and 18.502. In the Chucal section (69°05'55"-18°43'05") Miocene ignimbrites of 11 Ma (top of Chucal Formation) is characterized respectively by 87Sr/86Sr =0.7068, eNd values = -7.3, TDM ages=1.2, and 206Pb/204Pb = 18.292. Sr-isotope compositions of ignimbrite represent mostly the amount of crustal contribution to the ignimbrite magmas. By contrast, Pb and Nd isotopes reflect a particular basement composition and allow us to search for equivalent isotope compositions in distrib-

uted stratovolcanoes located on the Western margin of the Altiplano, the presumed source area of the ignimbrites. The isotope signatures of Cuno Cuno ignimbrites are similar to Miocene andesite lavas of Firura and Saraccoto region. The Majes ignimbrites are similar to Miocene lavas of Huarancante and Ananto region. The Chucal ignimbrite is similar to Miocene lavas of Cerro Marquéz.

This finding combined with REE elements, geological map of the different volcanic arcs lends support to a petrogenetic provenance for Cuno Cuno, Majes and Chucal ignimbrites. The old volcanic centers from which the Cuno Cuno ignimbrites erupted actually are eroded and Quaternary lavas cover their sources. The volcanic center of Majes ignimbrites is the Miocene Nevado Huarancante (5342 m.a.s.l.) today composed of altered volcanic rocks, this center corresponds to the Huaylillas arc. The Volcanic center of Chucal ignimbrite is the likely in the region of the Marquéz volcano located to the west of the Western Cordillera.

Apart from locating possible source areas for these ignimbrites, the isotopic data now allow a better estimate of the mass balance between juvenile magmas (basalt and differentiated andesite) and crustal melting, because the crustal rocks that contribute to ignimbrite formation can be more tightly constrained. Therefore, we calculated mixing models between a mantle-derived magma and local crust, based only on the Sr- and Pb- isotopic ratios and concentrations. The crustal contribution to the ignimbrite magmas is quantified to have 19% in Cuno Cuno and Majes ignimbrites, and 10% in Chucal ignimbrite.

References

Mamani M., Tassara A.,Wörner G., (2008), Composition and structural control of crustal domains in the central Andes: Geochemistry Geophysics Geosystems, 9, doi:10.1029/2007GC001925.

Thouret J.-C., Wörner G., Gunnell Y., Singer B., Zhang X., Souriot T., (2007), Geochronologic and stratigraphic constraints on canyon incision and Miocene uplift of the Central Andes in Peru: Earth Plan Scien Lett, doi: 10.1016/j.epsl.2007.07.023.

Wörner G., Hammerschmidt K., Henjes-Kunst F., Lezaun J., Wilke H., (2000), Geochronology (40 Ar-39Ar-, K-Ar-, and He-exposure-) ages of Cenozoic magmatic rocks from Northern Chile (18°-22°S). Implications for magmatismo and tectonic evolution of the central Andes: Rev Geol Chile, 27, 205-240.

Early Caribbean-South American interaction: The evidence from Margarita Island, Venezuela

Maresch WV 1, Kluge R 2, Baumann A 3, Pindell J 4, Krückhans-Lueder G 5, Stanek KP 6

1 Inst. Geology, Mineralogy & Geophysics, Bochum, Germany; walter.maresch@rub.de

2 Inst. Mineralogy, Münster University, Germany (now at AQUANTA Hydrogeologie GmbH & Co. KG, Kirchplatz 1, 48301 Nottuln, Germany)

3 Inst. Mineralogy, Münster University, Germany

4 Tectonic Analysis Ltd., Chestnut House, Duncton, Sussex GU28 0LH England, also at Dept. Earth Science, Rice University, Houston, Tx 77002 USA

5 Inst. Mineralogy, Münster University, Germany (now at Tornescher Weg 150, 25436 Uetersen, Germany

6 Inst. Geology, TU Bergakademie Freiberg, 09596 Freiberg, Germany

The metamorphic rock sequences exposed on the Island of Margarita, Venezuela, located in the southeastern Caribbean plate boundary, are composed of a high-pressure/low-temperature (HP/LT) nucleus subducted to at least 50 km depth, now structurally overlain by lower-grade greenschist-facies units lacking any sign of high-pressure subduction-zone metamorphism (e.g. Stöckhert et al., 1995). The HP/LT nucleus involves protoliths of both oceanic (metabasalts and intimately associated carbonaceous schists of the La Rinconada unit; ultramafic massifs) and continental affinity (metapelites, marbles and gneisses of the Juan Griego unit). All HP/LT units were joined together prior to the peak of high-pressure metamorphism, as shown by their matching metamorphic pressure-temperature evolution. The metamorphic grade attained produced barroisite as the regional amphibole. Glaucophane is not known from Margarita. Contrary to a widely propagated assumption, there are no major nappe structures post-dating HP/LT metamorphism anywhere within the high-pressure nucleus of Margarita Island. U-Pb zircon dating of key trondhjemitic to granitic intrusive rocks provides the following constraints: 1) the Juan Griego unit is heterogeneous and contains Palaeozoic as well as probable Mesozoic protolith; 2) the peak of HP/LT metamorphism, i.e. maximum subduction, is younger than 114–106 Ma (intrusive age of overprinted trondhjemite) and older than 85 Ma (age of post-HP/LT granitic intrusives), most probably c. 100–90 Ma, a time span during which the northern South American margin was clearly a passive margin (Pindell & Drake, 1998).

The assembly of Margaritan protoliths and their HP/LT overprint occurred far to the west, off western northern South America, a scenario completely in accord with the details of the Pacific-origin model as outlined and updated by Pindell & Kennan (2009): Late Jurassic rifting in NW South America led to an Andean intra-arc basin, which opened during the Neocomian to form a back-arc basin floored by oceanic sequences (protoliths of La Rinconada tholeiites and associated ultramafic rocks, either underlying the tholeiites or as rifted continental margin), and

providing a catchment for sediments (Juan Griego unit) both on the continental margin and the back-arc floor. By 120 Ma, intra-arc extension had ceased and the Caribbean Arc was converging with the western flank of the Antioquia Terrane, closing the back-arc basin by arc-continent collision. La Rinconada-type basaltic crust and ultramafic rocks of the back-arc floor as well as marginal sediments and thinned continental crust of the South American margin were overridden by the active arc, subducted and subjected to HP/LT metamorphism. Slab anatexis at depth provided a source for intimately associated trondhjemites (e.g. Lázaro & García-Casco, 2008). Subduction culminated at 100-90 Ma. Concurrently, eastward-dipping subduction of Farallon lithosphere from outboard and beneath the newly accreted arc and Antioquia Terrane was renewed, thus allowing continued Caribbean-South America relative plate motion. The units of the "Margarita high-pressure metamorphic nucleus" lay just north of this new subduction zone such that they migrated north-northeastward with the Caribbean Arc (forearc) along the dextral Antioquia-Caribbean shear zone. In the transform setting, Margarita underwent intense dextral shear and progressive exhumation throughout the Late Cretaceous. By 85 Ma, the HP/LT complex was intruded by island arc magmas due to the subduction of Proto-Caribbean crust beneath the leading edge of the Caribbean Plate. The HP/LT rocks continued their exhumation to mid-crustal levels, perhaps by upward wedging of tectonic slivers but more likely by axis-parallel extension during transpression (e.g. Chevalier et al., 1988; Stöckhert et al., 1995). Dextral shearing and eastward translation continued. By 56 Ma, Margarita had rounded the Guajira salient, and was en-route to its Middle Miocene collision with central and eastern Venezuela.

References

Chevalier Y, Stephan J-F, Darboux J-R, Gravelle M, Bellon H, Bellizzia A, Blanchet R (1988) Obduction et collision pré-Tertiaire dans les zones internes de la Chaîne Caraïbe vénézuélienne, sur le transect Ile de Margarita-Péninsule de Araya. Comptes rendues de la Academie des Sciences Paris 307(II): 1925-1932.

Lázaro C, García-Casco A (2008) Geochemical and Sr-Nd isotope signatures of pristine slab melts and their residues (Sierra del Convento mélange, eastern Cuba). Chemical Geology 255: 120-133.

Pindell JL, Drake CL (1998) Paleogeographic Evolution and Non-glacial Eustasy, northern South America; (eds.) SEPM (Society for Sedimentary Geology), Special Publication 58, Tulsa, OK, 324pp.

Pindell J, Kennan L (2009) Tectonic evolution of the Gulf of Mexico, Caribbean and northern South America in the mantle reference frame: an update. In: James K, Antonieta-Lorente M, Pindell J (eds) The geology and evolution of the region between North and South America, Geol Soc London SpecPub, in press.

Stöckhert B, Maresch WV, Brix M, Kaiser C, Toetz A, Kluge R, Krückhans-Lueder G (1995) Crustal history of Margarita Island (Venezuela) in detail: constraint on the Caribbean plate-tectonic scenario. Geology 23: 787-790.

Distinguishing crustal segments in the North Patagonian Massif, Patagonia

Martínez Dopico CI 1, López de Luchi MG 2, Rapalini AE 3

1 Instituto de Geofísica Daniel A.Valencio, Departamento de Ciencias Geológicas, FCEyN, Universidad de Buenos Aires. E-mail: carmenmd@ingeis.com.ar

2 Instituto de Geocronología y Geología Isotópica (INGEIS), Universidad de Buenos Aires-CONICET

3 Instituto de Geofísica Daniel A.Valencio, Departamento de Ciencias Geológicas, FCEyN, Universidad de Buenos Aires- CONICET

Throughout the Paleozoic the North Patagonian Massif (NPM), northern Patagonia has been proven to be a place where granitic magmatism and mixing of crustal melts was a repetitive geological event. In order to evaluate their sources we integrated new Sm-Nd data with all the reliable previous data (Pankhurst et al., 2006; Varela et al., 2005, Rapela et al., 1992, Dalla Salda et al., 1991 and references therein) for the main Paleozoic igneous, sedimentary and metamorphic events in the NPM and recalculated them under the assumptions made by Wu et al. (2003) for the model age calculations.

The oldest crustal segment is identified in the early Cambrian fine to medium-grained metasediments of the Nahuel Niyeu, El Jagüelito and Mina Gonzalito formations in the northeastern border of the NPM and in the Lower Carboniferous Cushamen Formation schists in its western border as formed in Upper Paleoproterozoic between 1.6 to 2.1 Ga with a repetitive 1.6-1.8 Ga interval within.

In northeastern NPM, Valcheta and Sierra Grande areas, Ordovician granitoids intrude the low grade metaclastic units. TDM model ages between 1.45-1.57 Ga and εNd(t) ~ -2.7 for these granites suggest a subordinate juvenile input to the bulk crustal segment. This fact agrees with both microgranular enclaves and field and textural evidence of magma hybridization (Rapalini et al., 2009). Isolated Ordovician stocks north of the Rio Colorado river (Pankhurst et al., 2006), have bulk TDM model ages (~1.6 Ga) and crust-derived εNd(t) ca. -5, suggesting recycling of the oldest crustal segment. Upper Paleozoic magmatism is represented in Valcheta by the deformed granitoids of the Yaminué Complex (YC) and the Navarrete Plutonic Complex (NPC). The YC exhibits TDM values between 1.5 to 1.6 Ga, mean fSm-Nd values -0.34 to -0.53 and spread of εNd(t) between -3.6 to -6.1. These values typify different degrees of recycling in the bulk crustal segment as

well as being a reflection of the different protoliths involved. However, all cases show a main continental crust recycling as demonstrated by the crustal εNd(t). Regarding the Permian magmatism, NPC shows distinct episodes of mixing of unequal parts of an old recycled crust with new inputs of a slightly depleted mantle-derived magmas as demonstrated by the wide range in εNd(t) and TDM ages 1.3- 1.6 Ga. TDM model ages for the calc-alkaline granodiorite of the Aranda facies (recently defined by López de Luchi et al., 2009) at Pto. Navarrete show values of 1.3 Ga and relatively radiogenic εNd(t) values (-2.08) suggesting a rejuvenation yielded by a new magma input to the already recycled bulk crustal segment. The age of this bulk crustal segment could be considered as younger than 1.6 Ga as a result of the processes of magma addition during Ordovician times and the melting homogenization evidenced by the Yaminué Complex. In contrast, the high K-calc-alkaline series of the Upper Permian San Martin Granodiorite shows 1.5Ga TDM ages and εNd(t) -5.3, which could be explained as pure recycling of the bulk crust.

The Colohuincul Complex (CC) has been always recognized as the oldest rocks on the western NPM, even after the recent revealing group of Upper Silurian-Devonian Rb-Sr and U-Pb ages obtained by Varela et al. (2005) and Pankhurst et al. (2006), among others. Collected data for the CC involves the well-established Devonian orthogneisses, migmatites and granodiorites that crop out in San Martín de los Andes, Sañicó, Laguna del Toro and probably Sierra del Medio. These rocks yielded TDM model ages between 1.6 to 1.75 Ga, besides an isolated value of 2.1 Ga in a metadioritic enclave in Sañicó area. The εNd(t) indicates a consistent mean -5 and isolated much more negative values in the Sañicó-Comallo area. Widespread Devonian tonalitic magmatism shows slightly different Sm-Nd isotopic parameters: model ages indicate 1.4 Ga and εNd(t) calculations yielded a -4 mean value in spread range. The Sm-Nd signature of Paleozoic basement of the Northern Patagonian Andes in Chile and Argentina was studied by Lucassen et al. (2004), who found single stage-TDM model ages between 1.6 to 2.1 Ga. This data as well as ours confirm that the bulk crustal age at Early Paleozoic times would be 1.6 to 2.1 Ga partially in agreement with the bulk crustal background age observed at the same moment in the northeastern area of the NPM. This may allow us to propose a mechanism of main crustal recycling with a little new juvenile addition to the bulk crustal background as responsible for the Devonian tonalitic invasion and concomitant migmatization event. Lucassen et al. (2004) also provides a Rb-Sr isochron for a migmatite near San Martín de los Andes that points towards a 368 Ma age. We cannot discard some kind of exclusively-recycling processes in local areas as reflected by the upper crustal ISr signature and 1.5 Ga model age of the gneisses in Lago Curruhué (Pankhurts et al., 2006). The scenario for the juvenile addition, homogenization and recycling would be a thermal event congruent with an evolved arc and evidenced by the widespread Devonian tonalites, gneisses and tonalitic migmatites that crop out in the area as previously mentioned by Godoy et al. (2008). Furthermore based on the Sm-Nd signature, this Devonian magmatic

event could be extended farther south to Gastre area, where Pankhurst et al. (2006) obtained a reliable U-Pb 371± 3 Ma age in orthogneiss of the Laguna del Toro sector. South Bariloche, near 41°30´S the Early Carboniferous (~320Ma) amphibolites and granodiorites of the Cañadón de la Mosca arc- related rocks crop out (Pankhurst et al., 2006). These lithologies could correspond to a subduction-processed subcontinental lithosphere in the region where the amphibolites are believed to be derived from a mantle wedge slightly contaminated with subducted sediments. This event is evidenced by their positive to slightly negative γNd(t) values (-0.6 to + 2.8), closer to the depleted mantle source, and lower ISr (0.703-0.704). All the samples show Neoproterozoic TDM model ages (0.8-1.1 Ga) which argues for new inputs of juvenile magma to the crustal segment without significant crustal contamination. The Early Permian medium K- calc-alkaline igneous suites of the Mamil Choique Sierra and Rio Chico area exhibit mean 1.25- 1.34 Ga TDM model ages. The εNd(t) values for these rocks rank between -3.2 to -5.2 with almost the same fSm-Nd (-0.45). Considering the repetitive events of juvenile additions plus all the recycling events that have been produced in the continental crust, the bulk crustal composition during Permian times would have changed from the one in early Paleozoic times.

U/Pb ages of the oldest rocks exposed in the MNP hold considerably different values in the northeastern corner, where metasedimentary units have proven to have a minimum Cambro-Ordovician inheritance and Famatinian metamorphism, respect to the western, where minimum reliable ages of metamorphism indicate Devonian times. However, Pb and Sm/Nd whole rock isotopic compositions delineate only one basement domain. The crust in both areas was apparently formed during the Paleoproterozoic between the 1.7 to 2.1 Ga, and then subsequently recycled with minor additions of juvenile material during the Neoproterozoic. The first stage of crustal growth is evidenced from the Ordovician granites whose material were extracted from a fairly Mesoproterozoic depleted-mantle. Meanwhile in the western belt minor Mesoproterozoic juvenile addition can be assessed on certain εNd(t) values and field evidence. Hence, for these times the main crustal-forming mechanism would be the recycling of the bulk crust. On the other hand, the coeval Carboniferous to Permian intrusions in northeastern and western of the NPM were formed as an old Mesoproterozoic already recycled crust partially contaminated with a fairly low proportion of juvenile material, probably related with the granites and amphibolites of the Cañadón de la Mosca.

This abstract is partially extracted from an ongoing study on the North Patagonian Massif, the analysed data and incoming results are part of a major paper in progress. We especially acknowledge Dr. Ilka Schönberg (Georg August Universitat Goettingen) and Dr. María Elena Cerredo (CONICET) for fruitful discussions.

References

Dalla Salda L., Cingolani C., Varela R., 1991. El basamento pre- andino ígneo-metamórfico de San Martín de los Andes, Neuquén. Rev. de la Asoc. Geol. Arg., 46 (3-4):223-234

Godoy, E., Hervé, F. Fanning, M., 2008. Edades U-Pb SHRIMP en granitoides del macizo Norpatagónico: Implicancias geotectónicas Actas 17º Congreso Geológico Argentino, Jujuy: 1288-1289.

López de Luchi, M.G., Rapalini, A.E., Tomezzoli, R.N., 2009. Magnetic Fabric and Microstructures of Late Paleozoic granitoids from the North Patagonian Massif: Evidence of a collision between Patagonia and Gondwana?. Tectonophysics (In press).

Lucassen, F., Trumbull, R., Franz, G., Creixell, C., Vásquez, P., Romer, R.L., Figueroa, O., 2004. Distinguishing crustal recycling and juvenile additions at active continental margins: the Paleozoic to recent composition of the Chilean Pacific margin (36-41°S). Jour. of South Am. Earth Sci., 17: 103-119.

Varela, R., Basei, M.A.S., Cingolani, C.A., Siga, O.Jr, Passarelli, C.R. (2005) El basamento cristalino de los Andes Norpatagónicos en Argentina: geocronología e interpretación tectónica. Rev. Geol. de Chile 32 2: 167-187.

Pankhurst, R.J., Rapela, C.W., Fanning, C.M., Márquez, M. 2006. Gondwanide continental collision and the origin of Patagonia. Earth Sci. Rev. 76:235-257.Rapalini, A.E., López de Luchi, M.G., Martínez Dopico, C., Lince Klinger, F., Giménez, M., Martínez, P., 2009. Did Patagonia collide against Gondwana in the Late Paleozoic? Some insights from a multidisciplinary study of magmatic units of the North Patagonian Massif. GeoActa (In Press)

Rapela C. W., Pankhurst R., Harrison S. M., 1992. Triassic "Gondwana" granites of the Gastre district, North Patagonian Massif. Transactions of the Royal Society of Edinburgh, Earth Sciences 83, 291-304.

Wu, F.Y., Jahn, B.M., Wilde, S.A., Lo, C., Yui, T.F., Lin, Q., Ge, W.C., Sun, D.Y., 2003. Highly fractionated I-type granites in NE China (II): isotopic geochemistry and implications for crustal growth in the Phanerozoic. Lithos, 67:191-204.

Bulk-rock geochemistry of the meta-igneous rocks from the Tandilia Range, Argentina

Martínez JC 1 Dristas JA 2, Massonne H-J 3, Theye T 3

1 INGEOSUR-CONICET, Universidad Nacional del Sur, Argentina,jcmartin@uns.edu.ar
2 CIC and INGEOSUR-CONICET, Universidad Nacional del Sur, Argentina.
3 Institut für Mineralogie und Kristallchemie, Universität Stuttgart, Germany.

The Paleoproterozoic basement of the Tandilia Range, central-eastern Argentina, is the southernmost portion of the Río de la Plata Craton, which is mainly exposed in

Uruguay. This basement is composed of igneous rocks and metamorphic rocks of the greenschist, amphibolite and granulite facies (Teruggi and Kilmurray, 1975). The metamorphic rocks are derived from sedimentary and igneous protoliths. The igneous rocks of the basement of the Tandilia Range are mainly acid plutonic or hypabysal rocks. However, basic undeformed dykes also occur. Polymetamorphic events and heterogeneous deformation are recorded in almost all basement rocks of the Tandilia Range. This basement, also known as the Buenos Aires Complex (Marchese and Di Paola, 1975), is overlaid by a marine Neoproterozoic – Early Paleozoic sedimentary succession. Our study presents new whole-rock chemistry (XRF) data and discrimination diagrams of major, minor and trace elements from petrographically studied igneous and metamorphic samples of the Tandilia Range in order to contribute to a better reconstruction of the geodynamic environment especially of this part of the Rio de la Plata Craton. Our samples are from four areas: (1) north of Barker and Sierra Alta de Vela, (2) Balcarce, (3) Azul and (4) Olavarría.

The studied metamorphic rocks comprise migmatites, gneisses, calc-silicatic marbles, and amphibolites. Migmatites generally present a granoblastic texture and a dioritic to granitic composition according to the TAS chemical classification diagram (Cox et al., 1979). Invasive leucocratic material in migmatites indicates an open system precluding a chemical definition of its precise protolith. Such rocks together with gneisses, which are not abundant without migmatitic texture, and calc-silicate rocks (skarn mineralogy) characterize the stratified basement derived from sedimentary protoliths. Samples of quartz-dioritic to granitic composition (TAS classification), collected southeast of the town of Tandil, show granoblastic to lepidoblastic texture. The mineral assemblage in these rocks is quartz, plagioclase, K-feldspar, biotite occasionally with hornblende and garnet. An N-MORB normalized spider diagram displays enrichment in large ion lithophile elements (Cs, Ba, Rb and K) and a slightly depleted concentration in HREE. Rare earth element (REE) patterns normalized to chondrite (Taylor and McLennan, 1985) show a negative Eu anomaly with LREE enrichment.

Data of the whole-rock chemistry of granoblastic to nematoblastic amphibolites plotted in the bivariant diagrams Zr/Ti - Ni and TiO_2 - Ni (Winchester et al., 1980) suggest basic igneous protoliths for all such samples because of Zr/Ti < 1. These rocks consist of the main mineral assemblage hornblende and plagioclase occasionally with some quartz. The amphibolites form boudinaged bodies commonly less than 2 m wide and 20 m long. They are interlayered in granodioritic-tonalitic migmatites as it is, for instance, discernible in the northern Barker area. Classification of the amphibolites using the $Zr/Ti_2O*0.0001$ - Nb/Y diagram (Winchester and Floyd, 1977) leads to an alkaline to subalkaline nature for these rocks. On the other hand, the ternary discrimination diagram 2Nb - Zr/4 - Y (Meschede, 1986) points to E-MORB type and within-plate tholeiite affinities. The data of all samples plot along a tholeiitic trend in the AFM diagram. REE diagrams normalized to chondrite (Taylor and McLennan, 1985) display an enrichment in LREE.

The studied granitoids, which are emplaced into the stratified crystalline basement, range in composition from granites to diorites, mostly with calcic to calc-alkaline character, according to the classification diagrams based upon SiO_2 – Na_2O+K_2O (Cox et al., 1979). In addition, most analysed granitoids are peraluminous with a slight tendency to a metaluminous character. The discrimination diagrams Rb - Y+Nb and Rb - Yb+Ta (Pearce et al., 1984) point to granites typical of an active continental margin (VAG) and within-plate (WPG) environment. Besides, syn-collisional and late to post-collisional granitoids were established by the ternary diagram Rb/30 - Hf - Ta*3 (Harris et al., 1986), which seems to be more appropriate for the derivation of a geodynamic environment using geochemical data. REE patterns normalized to chondrite (Taylor and Mc Lennan, 1985) show a gentle slope with LREE enrichment and $(La/Yb)_N$ » 3. Negative Eu (Eu/Eu*= 0.18 – 0.85) anomalies in most granitoids indicate feldspar fractionation in the corresponding magma sources. In addition, N-MORB normalized spider diagrams point to enrichment of large ion lithophile elements (Cs, Ba, Rb and K). It is noteworthy to mention the similar pattern of (preserved) granitoids and corresponding metamorphic rocks, migmatites and gneisses.

This studied crystalline basement is reminiscent of a complex igneous and metamorphic evolution of the southernmost portion of the Río de la Plata Craton involving events of subduction and continent-continent collision.

References

Cox KG, Bell JD, Pankhurst RJ (1979) The interpretation of igneous rocks. Allen and Unwin, London, 445 pp.

Frisicale M, Dimieri L, Dristas J (1999) Megacizalla en Boca de la Sierra, Tandilia: Convergencia normal? 14º Congreso Geológico Argentino Actas 1: 168-171.

Harris NBW, Pearce JA, Tindle AG (1986) Geochemical characteristics of collision-zone magmatism. In: Coward MP, Reis AC (eds) Collision tectonics. Spec Publ Geol Soc 19: 67-81

Marchese HG, Di Paola EC (1975) Reinterpretación estratigráfica de la Perforación Punta Mogote Nº 1, Provincia de Buenos Aires. Rev Asoc Geol Arg 30: 17-44

Meschede M (1986) A method of discriminating between different types of mid-oceanic ridge basalts and continental tholeiites with the Nb–Zr–Y diagram. Chem Geol 56: 207-218

Pearce JA, Harris NBW, Tindle AG (1984) Trace element discrimination diagrams for the tectonic interpretation of granitic rocks. J Petrol 25: 956-983

Taylor SR, McLennan SM (1985) The Continental Crust: Its composition and Evolution. Blackwell, London, 312 pp

Teruggi ME, Kilmuray JO (1975) Tandilia. 6º Congreso Geológico Argentino, Relatorio Geología de la Provincia de Buenos Aires: 55-77.

Winchester JA, Floyd PA (1977) Geochemical distributions of different magma series and their differentiation products using immobile elements. Chem Geol 20: 325-343

Winchester JA, Park RG, Holland JG (1980) The geochemistry of Lewisian semipelitic schists from the Gairloch District, Wester Ross. Scot J Geol 16: 165-179

Hydrothermal alteration patterns in Tandilia Ranges, Olavarría area, Argentina

Martínez JC 1, Dristas JA 2, Massonne H-J 3, Theye T 3, van den Kerkhof AM 4

1 INGEOSUR-CONICET, Universidad Nacional del Sur, Argentina.
2 CIC/INGEOSUR-CONICET, Universidad Nacional del Sur, Argentina. jdristas@criba.edu.ar
3 Institut für Mineralogie und Kristallchemie, Universität Sttutgart, Germany.
4 GZG, Universität Göttingen, Germany

The southernmost part of the Rio de la Plata Craton, Tandilia Ranges, consists of igneous-metamorphic basement, known as Buenos Aires Complex (Di Paola & Marchese 1974) and a Neoproterozoic-Early Palaeozoic shallow marine succession. The former is mainly composed by granitoids, migmatites, amphibolites, gneisses, mylonitic rocks, metavolcanic rocks and marbles (Cingolani & Dalla Salda, 2000, Pankhurst et al., 2003, Delpino & Dristas, 2007). These rocks are largely related to the Transamazonia Orogenic cycle, ca. 2200-1800 M.a., (Cingolani & Dalla Salda, 2000). In the Olavarría area, northern Tandilia Ranges, the siliciclastic and carbonatic Sierras Bayas Group (Poire, 1987) overlies a large crystalline lithological variety of rocks.

Hydrothermal fluid flow has previously been registered and characterized in altered rocks from Barker-Villa Cacique area (Martínez and Dristas, 2007), a hundred kilometres southwestwards from Olavarría, into the Tandilia Ranges. Field trip observations in the latter area, petrographic studies, electron microprobe, X-ray diffractometry and bulk-rock analyses of collected samples allowed to established different alteration patterns affecting three stratigraphic levels:

(1) Buenos Aires Complex-Sierras Bayas Group unconformity. Altered samples from Villa Mónica quarry and drill core samples at El Polvorín quarry show a dominant chloritic-carbonatic and sericitic alteration. The basement from Villa Mónica quarry includes granitoids of granodioritic to granitic composition and amphibolitic migmatites. All these primary minerals display some degree of ductile deformation especially developed in quartz. Accessory minerals include zircon, apatite and allanite. In the eastern side of the quarry hydrothermal fluids generated chloritised tight fault planes of aptitude N50°/80°NW as a result of a later fragile event which also affected the sedimentary cover. A few meters below the

unconformity this chloritised basement is cross cut by veinlets. Whereas, basement is sericitised immediately below the well-known quartz arenites of the lower section of Sierras Bayas Group. In the same way, the sabulitic to coarse-grained arkose arenite from the lowermost part of sedimentary succession display a fine-grained sericitic alteration matrix. The same alteration pattern has been recognised in wacke sandstones from drill core sample at the unconformity in El Polvorín quarry. There, scarce K-feldspar clasts are replaced by sericite, apatite, calcite and chlorite. Tiny apatite LREE-bearing, anatase and barite crystals are scattered into the alteration matrix. Carbonates Mg-Fe and Sr-bearing pervasively altered the basement immediately underling wacke sandstones. Vermiculite and Fe-oxides alter and stain biotite, whereas crystals of K-feldspar are altered relics. Secondary apatite crystals usually content LREE (Ce, La, and Pr) and barite is commonly present. No fresh basement was reached in drill core, up to 5 m deep, below the contact with sedimentary rocks (75 m from surface). Altered sedimentary rocks and igneous-metamorphic basement in the unconformity zone exhibit similar REE patterns normalized to chondrite (Taylor and McLennan, 1985), where light REE are slightly enriched and heavy REE pattern are flat.

(2) Quartz arenites, dolostones and associated pelitic rocks at El Polvorín and Piedra Amarilla quarries. Veins of goethite-hematite are commonly cutting and replacing quartz arenite levels. In dolostones previous recrystallised dolomite rombohedrons are partly to completely replaced by interstitial hydrothermal secondary quartz, with development of druses. Drill core samples of dolostone at el Polvorín quarry display breccia zones where fragments of clayey material, frequently with grains of deformed quartz basement-derived, are cemented by secondary carbonate and idiomorphic quartz. Anhedral anatase crystals (up to 0.5 mm) are scattered through this breccia rock. Lentiform clay levels, interlayered between dolostones and quartz arenites of the upper stratigraphic unit are originally composed by illite. These and the lowermost part of upper quartz arenites are commonly brecciated and altered by whitish clay assemblage (sericite + pyrophyllite + kaolinite). LREE-bearing APS minerals are commonly scattered into this clay secondary assemblage. Brecciated microcrystalline secondary quartz associated with pyrophyllite affected this zone.

(3) The unconformity zone between the black limestones of upper Sierras Bayas Group level and the siltstones and marls of the Cerro Negro Fm. in El Polvorín, Puracal and Loma Negra quarries. Replacement of previous micrite, calcite and barite veining, dissolution and collapse of the upper sediments and breccia body intrusions are common features pointing to hydrothermal fluid migration, specially channelled through the unconformity surface. Veining and dykes of clayey and silty ascending material through the limestone and upper unit also point to hydrothermal fluid flow.

Additional studies on isotopy, cathodoluminiscence and fluid inclusion are programmed in order to constrain fluids temperature, composition and further effects over altered rocks.

References

Delpino SH and Dristas JA (2007) Dolomitic marbles and associated calc-silicates, Tandilia belt, Argentina: Geothermobarometry, metamorphic evolution, and P-T path. J. S. Am. Earth Sci., doi:10.1016/j.james.2007.06.001

Cingolani CA and Dalla Salda L (2000) Buenos Aires cratonic region. En T. Filho & A. Misi (ed) Tectonic Evolution of South America: 139-147.

Di Paola EC and Marchese HG (1974) Relación entre la tectonosedimentación, litología y mineralogía de arcillas del complejo Buenos Aires y la Formación La Tinta (Prov. de Buenos Aires). Rev. Asoc. Argentina de Mineralogía, Petrología y Sedimentología, 5 (3-4): 45-58.

Martínez JC and Dristas JA (2007) Paleoactividad hidrotermal en la discordancia entre el Complejo Buenos Aires y la Formación La Tinta en el área de Barker, Tandilia. Rev. Asociación Geológica Argentina 62 (3): 375-386.

Pankhurst RJ, Ramos VA and Linares E (2003) Antiquity of the Rio de la Plata Craton in Tandilia, Southern Buenos Aires Province, Argentina. J S Am Earth Sci 16: 5-13.

Poiré, DG (1987) Mineralogía y sedimentología de la Formación Sierras Bayas y en el núcleo Septentrional de las sierras homónimas, partido de Olavarría,, provincia de Buenos Aires. Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Doctoral Thesis nº 494, 271 p. (unpublished).

Taylor SR and McLennan SM (1985) The Continental Crust: Its composition and Evolution. Blackwell, London, 312 pp.

High-pressure, medium-temperature metamorphic rocks in the Ecuadorian Cordillera Real - Evidence for continental collision

Massonne H-J 1, Toulkeridis T 2

1 Inst. f. Mineralogie und Kristallchemie, Universität Stuttgart, Germany, h-j.massonne@mineralogie.uni-stuttgart.de

2 Center of Geology, Volcanology and Geodynamics, Universidad San Francisco de Quito, Ecuador

The Cordillera Real in Ecuador is part of the Northern Andean Chain and is made up of Mesozoic to Quaternary volcano-sedimentary sequences and a metamorphic basement. The rocks of this basement are exposed in the scars formed by the drainage system directed towards the Subandean zone and the western Amazonian basin. Samples of our recent study, mainly various orthogneisses and metapelites, were taken along two east-west profiles crossing the entire metamorphic belt east of Quito and ca. 130 km south of Quito. The metapelites, typically with abundant

quartz, chlorite and potassic white mica as well as some plagioclase, can also contain chloritoid and garnet as reported earlier, for instance, by Pratt et al. (2005). Garnet was also found in orthogneisses coexisting with other mafic phases such as amphibole, biotite, epidote, chlorite, and potassic white mica.

Some of the sampled rocks were studied in detail with an electron microprobe. Bulk compositions of these rocks were obtained with an X-ray fluorescence spectrometer. In all samples, we found phengites pointing to higher metamorphic pressures. These phengites contain Si contents per formula unit (pfu) of up to (1) 3.25 in Al-rich metapelites (typically containing chloritoid), (2) 3.35 in metapelites with more ordinary compositions and (3) 3.45 in orthogneisses. For instance, metapelite sample CR1-6D shows mm-sized garnet (~ 1 vol%) which are concentrically zoned. The composition of the core and the mantle of this mineral is about $Alm_{70}Gros_{20}Pyr_5Spes_5$ and $Alm_{78}Gros_{13}Pyr_8Spes_1$, respectively. The outermost garnet mantle is composed of $Alm_{77}Gros_{15}Pyr_7Spes_1$. Potassic white mica shows at least two growth generations in CR1-6D. As observed in the majority of the other well studied rocks, phengite cores are rich in Si (3.29-3.33 pfu in CR1-6D) whereas the rims are poorer in Si (around 3.20 pfu in CR1-6D). Albite typically occurs as mm-sized porphyroblast with abundant in-clusions. Among these inclusions are relics of amphibole, a tschermakitic hornblende. Further minerals of the assemblage in CR1-6D are biotite, chlorite, and epidote.

In order to derive P-T paths for the well-studied rocks we applied conventional geothermobarometry but also the technique of calculating P-T pseudosections for a fixed rock composition using thermodynamic data of minerals. For the latter technique a newer version of the computer program package PERPLE_X (Connolly, 1990) and the thermodynamic data set by Holland and Powell (1998) was applied. For the metapelite CR1-6D we could reconstruct a P-T path starting at about 14 kbar and 525°C, at which garnet and phengite cores would have been in equilibrium. Peak temperature conditions (garnet mantle) were ca. 560°C at 12-13 kbar. The retrograde path passed through the P-T conditions of 7-8 kbar at ca. 500°C. At these conditions albite porphyroblasts as well as rims of potassic white mica newly formed. The outlined P-T path refers probably to all kind of basement rocks close to the western end of the sampled profiles, where the basement submerses below a volcano-sedimentary sequence. It appears so far, that the basement of the sampled area there shows the maximum P-T conditions discernible in the entire Ecuadorian Cordillera Real. Lower grade rocks occur in the eastern portions of our sampled profiles (see also Pratt et al., 2005). However, the peak pressure conditions for these rocks were still somewhat above 10 kbar indicating typical conditions of the blueschist-facies.

The above outlined P-T path as well as the corresponding rock CR1-6D resembles strongly the metamorphic conditions as well as the rocks in the Guarguaraz Complex of the Argentine Cordillera Frontal. The high-pressure metamorphism in this complex was interpreted to be the result of continental collision between Gondwana and the microcontinent Chilenia (Massonne and Calderón, 2008)

probably in Devonian times. A similar geotectonic scenario is invoked for the studied rock assemblage of the Ecuadorian Cordillera Real especially because even orthogneisses were involved in the referred high-pressure metamorphism. However, it is at the present stage of this study not clear which potential continental plate (or fragment of it) collided with the South American continental plate. In addition, the age of the high-pressure metamorphism in the Ecuadorian Cordillera Real is still uncertain. Our first attempt to date tiny monazite grains in one of the lower grade metapelites with the electron microprobe failed because the lead content was below the detection limit. Nevertheless, the corresponding ages must be below 50 million years. In contrast to this finding, Aspden et al. (1992) reported a geotectonic event in the Late Cretaceous (65-85 Ma) as the latest datable event. If we would relate these Cretaceous to Tertiary ages to the above reported high-pressure metamorphic event, we would conclude that more than just an oceanic plateau collided with northwestern South America as it was proposed, for instance, by Reynaud et al. (1999), Bosch et al. (2002) and Hughes and Pilatasig (2002) for Cretaceous to Palaeogene times. Alternatively, the high-pressure metamorphism could be older and, thus, would lead to the potential discovery of a so far unknown continental fragment which had collided with northwestern South America.

References

Aspden JA, Harrison SH, Rundle CC (1992) New geochronological control for the tectonic metamorphic evolution of the metamorphic basement, Cordillera Real and El Oro Province of Ecuador. J South Am Earth Sci 6: 77-96

Bosch D, Gabriele P, Lapierre H, Malfere J-L, Jaillard E (2002) Geodynamic significance of the Raspas Metamorphic Complex (SW Ecuador): geochemical and isotopic constraints. Tectonophys 345: 83-102

Connolly JAD (1990) Multivariable phase diagrams; an algorithm based on generalized thermodynamics. Am J Sci 290: 666-718

Holland TJB, Powell R (1998) An internally consistent thermodynamic data set for phases of petrological interest. J Metamorphic Geol 16: 309-343

Hughes RA, Pilatasig LF(2002) Cretaceous and Tertiary terrane accretion in the Cordillera Occidental of the Andes of Ecuador. Tectonophys 345: 29-48

Massonne H-J, Calderón M (2008) P-T evolution of metapelites of the Guarguaraz Complex, Argentina - evidence for Devonian crustal thickening close to the western Gondwana margin. Rev Geol Chile 35: 215-231

Pratt WT, Duque P, Ponce M (2005) An autochthonous geological model for the eastern Andes of Ecuador. Tectonophys 399: 251-278

Reynaud C, Jaillard E, Lapierre H, Mamberti M, Mascle GH (1999) Oceanic plateau and island arcs of southwestern Ecuador: their place in the geodynamic evolution of northwestern South America. Tectonophys 307: 235-254

A sustentabilidade da mineração na Amazônia – o caso do Estado do Pará (Brasil)

Mathis A 1, Peregovich B 2, de Azevedo Mathis A 1

1 UFPA/NAEA–Núcleo de Altos Estudos Amazônicos, Belém-PA, Brasil, armin.mathis@gmail.com
2 UFPA – Universidade Federal do Pará, Marabá-PA, Brasil

O presente trabalho apresenta os resultados do projeto de pesquisa intitulado "Estudo acerca da sustentabilidade da mineração no Estado do Pará". A pesquisa foi realizada, no período de 2006 a 2008, por uma equipe multidisciplinar da Universidade Federal do Pará (UFPA) em parceria com o Serviço Geológico do Brasil (CPRM), o Departamento Nacional de Produção Mineral (DNPM), a Secretaria do Meio Ambiente do Estado do Pará (SEMA-PA) e a Secretaria de Estado de Desenvolvimento, Ciência e Tecnologia do Pará (SEDECT – PA) e contou com o financiamento da Financiadora de Estudos e Projetos (FINEP).

O Estado do Pará (1.253.164 km^2) ocupa 16,6% do território brasileiro e representa 26,1% da região amazônica brasileira. Apresenta uma população de 7,1 milhões de habitantes vivendo predominantemente em áreas urbanas. O Pará apresenta fontes de recursos minerais que compreende, entre outros: 85% das reservas nacionais de cobre; 80% das reservas nacionais de bauxita e cerca de 20% das reservas nacionais de ouro, ferro, manganês e níquel. O valor da produção mineral paraense no ano de 2007 atingiu de USD 4,0 bilhões, o que significa um aumento de 7% em relação ao ano anterior. A produção mineral é altamente concentrada, somente três minerais são responsáveis por 90% do valor dessa produção, a saber: minério de ferro (60%), cobre (15,4%) e, bauxita (14,7%).

Desse modo, o Estado do Pará, no cenário da produção mineral brasileira, é responsável por: 92% da produção de cobre, 91% da produção de bauxita, 85% da produção de manganês, 65% da produção de caulim. E o minério de ferro, o principal produto da produção mineral paraense, contribui para 29% da produção nacional. Grande parte dessa produção destina-se ao mercado externo e a participação no mercado interno fica reduzida à 5% da produção de caulim e 17% da produção de manganês. Nesse cenário, a única exceção diz respeito à produção de bauxita que é responsável pelo abastecimento das refinarias de alumina no Estado do Pará e no Estado do Maranhão. Com exceção da produção de ouro, a produção dos minerais anteriormente citados, aumentou consideravelmente no Estado do Pará, principalmente, a produção de caulim que cresceu 90% entre os anos de 2001 e 2007.

No mesmo período, a escassez dos minerais no mercado mundial aquecido pelo crescimento da economia da China provocou um aumento considerável nos preços, dentro dos quais se destacam: o preço do minério de ferro (+ 93%), do manganês (+86%) e dou ouro (80%).

No que tange a evolução dos empregos, em 2008, o setor extrativista mineral empregou no Pará 9.826 trabalhadores e se comparado ao ano de 2000, esse número representa mais do que o dobro de postos de trabalho ofertados na produção mineral. Esse valor representa 1,2% do total de empregos formais no Estado do Pará. A dinâmica da demanda no mercado de trabalho no setor da extração mineral foi expressiva em 2007. Nesse ano foram criados 1360 novos empregos formais no Estado do Pará, o que significa 2,4% do total dos novos empregos formais criados no Estado. Entretanto, a oferta de empregos fica concentrada em determinados municípios, como por exemplo, o município de Parauapebas que absorve mais da metade do valor acima identificado.

No que concerne à indústria de transformação de bens minerais observa-se a mesma tendência de crescimento registrada no setor extrativista mineral, porém, não alcança os mesmos níveis de empregabilidade. O setor empregou no final de maio de 2008 um total de 6.862 pessoas, e indica-se, um aumento de 70% em relação ao ano de 2000. No que se refere à indústria metalúrgica no Pará computa-se no final de maio de 2008 um total de 9.960 postos de trabalhos, e aponta-se um aumento de 45% em comparação com o ano de 2000.

O setor mineral no Estado do Pará é dominado pela Companhia Vale do Rio Doce (CVRD). A companhia foi criada como uma empresa estatal no ano de 1942, atuando inicialmente no Estado de Minas Gerais. A CVRD, depois da sua privatização no ano de 1997, mudou o enfoque da sua atuação. Deixou de atuar meramente no Brasil, transformando-se na segunda maior empresa mundial de mineração, e ampliou o seu portfólio de produtos além dos minerais ferrosos.

Foram previstos investimentos na ordem de USD 42 bilhões para os anos 2008 até 2011. Desse total mais da metade (USD 23,6 bilhões) é destinado para o Pará. Como principais objetivos da empresa destacam-se: a ampliação da produção de minério de ferro e de cobre, o início da produção de níquel, e a ampliação de sua presença na produção de alumínio.

Embora a extração mineral tenha mostrado um desempenho expressivo desde o ano de 2001, os seus resultados em termos de desenvolvimento regional ainda são muito restritos. A legislação nacional assegura para os municípios 65% do valor dos royalties pagos pelas empresas de mineração. No ano de 2007, o DNPM registrou atividades de mineração em 51 dos 143 municípios paraenses, que gerou uma compensação de USD 42 milhões, o que significa um aumento de 95% com relação ao ano de 2003. Observa-se uma nítida concentração de recursos nos municípios onde estão localizadas as minas de grande porte. Pode-se afirmar, a partir dos resultados da pesquisa em tela que essa renda destina-se particularmente para seis municípios e o município de Parauapebas, onde a CVRD extraí minério de ferro fica com mais da metade dos recursos disponíveis. Ao longo da exposição apresenta se um mapa panorâmico sobre a geologia dos recursos naturais no Estado do Pará, e evidencia-se: os principais distritos minerais do Pará, as principais substância minerais extraídas, e, a estrutura e distribuição espacial das minas no Estado do Pará. Ainda, busca-se desenvolver determinadas questões com im-

plicações sócio-ambientais sinalizadas a partir da pesquisa tais como; isenção de impostos e contribuições para os municípios; evolução dos empregos no setor extrativista mineral; a caracterização das indústrias de extração e transformação de minérios no Pará; a discussão sobre a responsabilidade social nas empresas de mineração; e o uso de substâncias minerais na construção civil na região metropolitana de Belém, capital do Estado do Pará.

Mediciones de susceptibilidad magnética con el equipo GMS-2 de Geoinstruments, Ltd. a escala de laboratorio

Méndez-Delgado S, García-Peña Á, Medina-Ferrusquía E L

Facultad de Ciencias de la Tierra, Universidad Autónoma de Nuevo León, México, smendez@fct.uanl.mx

En la exploración geofísica existen diferentes métodos de prospección, entre los cuales se pueden mencionar: Sísmico, Gravimétrico, Magnético y Geoeléctricos. A través de mediciones físicas relacionadas con dichos fenómenos se busca obtener, respectivamente: la velocidad de propagación de las ondas sísmicas, densidad de masa, susceptibilidad magnética y resistividad o conductividad eléctrica.

La susceptibilidad magnética está definida como la capacidad que tienen los materiales, en nuestro caso rocas, para adquirir una magnetización cuando están inmersas en un campo magnético. Comúnmente se mide directamente en el laboratorio o en campo a nivel de afloramientos. En el método magnético juega un papel similar al de la densidad de masa en el método gravimétrico. El conocimiento de la susceptibilidad magnética de muestras de roca o de afloramientos tiene usos en geología, magnetometría, arqueología y minería. Las mediciones de susceptibilidad magnética se pueden realizar con instrumentos portátiles como el equipo GMS-2 de Geoinstruments, Ltd.

Los instrumentos de medición de susceptibilidad magnética (susceptibilímetros) generalmente consisten en arreglos de bobinas. Según estudios previos (Méndez Delgado, 1992), la profundidad de investigación o zona de influencia de la medición depende de los arreglos de bobinas, su geometría, así como de la separación entre la muestra y el aparato. Mediante una ecuación es posible determinar la zona de influencia, la cual nos indica qué zonas influyen más en la medición (como una función de ponderación). Los equipos como el susceptibilímetro GMS-2 de Geoinstruments, Ltd. ordinariamente están calibrados para realizar las mediciones en contacto directo con la roca. En el caso de mediciones en vetas de materiales, se deben aplicar factores de corrección.

Tomando como base la función de influencia, se llevaron a cabo una serie de experimentos utilizando varios lotes de azulejos, con la finalidad de realizar modelado físico, es decir simular algunas estructuras geológicas (homogéneas, 1-D, 2-D y casi

3-D) con los azulejos para conocer el tipo de anomalías de susceptibilidad magnética producidas. Se utilizaron azulejos porque al fabricarlos adquieren cierta magnetización, se eligieron azulejos de varios lotes para tener bloques de diferente susceptibilidad magnética. De cada lote diferente de azulejos se seleccionaron los que presentaron valores más similares.

Medina Ferrusquía EL (2008) diseñó experimentos con estructuras 2 y casi 3-D, mostrando que las anomalías de susceptibilidad magnética son semejantes a las que se obtienen para mediciones de resistividad o gravimetría en perfil o planta. También realizó un experimento para simular al semiespacio homogéneo y utilizar el concepto de función de influencia; lo que permitió obtener funciones de ponderación que dependen de la profundidad. Como una prueba de los valores obtenidos experimentalmente se simuló un medio estratificado y se realizaron las mediciones de susceptibilidad, obteniendo buenos resultados.

Referencias

Medina Ferrusquía EL (2008) Modelado físico con el medidor de susceptibilidad magnética GMS-2 de Geoinstruments, Ltd. Tesis de Licenciatura, UANL. Facultad de Ciencias de la Tierra; Linares NL, México. 84 págs.

Méndez-Delgado S (1992) Caracterización de la zona de influencia de mediciones de susceptibilidad magnética. Tesis de Maestría en Ciencias CICESE Ensenada BC México

---

A statistical method based on historical eruption data for volcanic hazard assessment: applications to active volcanoes.

Mendoza-Rosas AT, De la Cruz-Reyna S

Instituto de Geofísica, Universidad Nacional Autónoma de México, Ciudad Universitaria, México 04510, México, ateresa@geofisica.unam.mx

The assessment of volcanic hazard is essential for disaster prevention. Finding an accurate distribution of repose periods between eruptions represents one of the main tools for the assessment of the volcanic hazard, i.e. the probability of new eruptions occurring within a given area and a time interval specific. The quality of the probability estimate depends on the statistical model chosen to describe the actual distribution of the repose intervals, particularly in a non-stationary eruption sequence. In this work, we use a mixture of exponentials distribution, namely the sum of exponential distributions characterized by different eruption occurrence rates and weighting factors. The most striking property of an exponential mixture density is that the shape of the density function is flexible in a way similar to the frequently used Weibull distribution, matching long tailed distributions and allowing clustering and time dependence of the eruption sequence, with distribution

parameters that can be readily obtained from the observed number of eruptions per unit time in specific VEI (Volcanic Explosivity Index) categories. We recommended the use of a mixture of exponential distributions when eruption regimes with well-defined eruption rates can be identified. Thus, the mixture of exponentials turns out to be more precise and much simpler to apply than the Weibull distribution, and can be also applied as well to eruptions in monogenetic volcanic fields. As an example, the mixture of exponential distributions is applyied on the repose-time sequences between explosive eruptions of Colima and Popocatépetl volcanoes, México, for a simple and precise assessment of their volcanic hazards, and the results are compared with the Weibull and other distributions.

Strain analysis of geodetic observation data in the Magallanes-Fagnano fault zone, Tierra del Fuego

Mendoza L 1, Dietrich R 2,. Perdomo R 1, Hormaechea JL 1,3, Del Cogliano D 1, Fritsche M 2, Richter A 2

1 FCAG, Universidad Nacional de La Plata, Argentine luciano@daad-alumni.de
2 IPG, Technische Universität Dresden, Germany
3 Estación Astronómica Río Grande, Argentinia

In this work we present the application of the strain analysis approach to site velocity vectors derived from repeated geodetic Global Positioning System (GPS) observations in order to investigate the deformation of the earth crust along an active tectonic plate boundary. The region under investigation is located in the southernmost part of South America, in the Argentine side of Tierra del Fuego island. It includes the Magallanes-Fagnano Fault System (MFFS), the only on- land segment of the South American/Scotia tectonic plates boundary. The MFFS represents a left- lateral transform fault.

The presented analysis is based on precise GPS observations in a network of 30 stations and spanning 14 years. Using the Bernese GPS software in combination with state-of-the-art strategies, models and products, site velocity vectors were determined for each station with an accuracy of less than 0.2 millimeter per year. The obtained horizontal velocities were used as an input for a strain analysis. Our results demonstrate that the strain analysis is a convenient tool to reveal and analyze the spatial pattern of the crustal deformation within the GPS network. Geodynamically stable regions are clearly distinguished from an active deformation zone along a 30 km-wide belt centered on the main trace of the fault system.

Within this deformation zone a change from stretching (transtensional deformation) on the East to predominant shortening (transpressional deformation) on the West is detected. Further in sights are obtained by the correlation of the strain rates with the vertical velocities and rotation rates. The identification of rigid zones

in either sides of the MFFS allows a more precise determination of the relative transform velocity between the South American/Scotia tectonic plates.

Estimación de la intensidad macrosísma para El Salvador y su incorporación al Sistema de Información Geográfica

Menjívar L 1, Reyes M 2, Alvarado L 2, Ramos A 2

1 Servicio Nacional de Estudios Territoriales, El Salvador lmenjivar@marn.gob.sv
1 Universidad Centroamericana "José Simeón Cañas", El Salvador

El Salvador está ubicado en la parte occidental de la placa tectónica del Caribe y se caracteriza por una intensa actividad sísmica, la cual se asocia principalmente al proceso de subducción de la placa de Cocos bajo la placa del Caribe y a fallas geológicas locales, ejemplos significativos de sismos generados por estas fuentes son los ocurridos el 10 de octubre de 1986 con magnitud 5.7 (Mw) y el 13 de enero de 2001 con magnitud 7.7 (Mw). Inmediatamente después de ocurrido un sismo las instituciones de atención a emergencias necesitan decidir rápidamente hacia dónde dirigir los recursos y la ayuda. Una forma de estimar los daños ocurridos después de un sismo es conociendo la intensidad macrosísmica, que a pesar de ser un parámetro subjetivo, facilita la identificación de daños y zonas más afectadas; esta puede ser calculada rápidamente utilizando ecuaciones de atenuación que relacionen parámetros de movimiento fuerte, distancias y características del sitio como la geología superficial. El monitoreo sísmico que se realiza en El Salvador está a cargo del Servicio Nacional de Estudios Territoriales (SNET), una dirección del Ministerio de Medio Ambiente y Recursos de El Salvador; cuya red permite conocer los parámetros físicos del movimiento del terreno pocos minutos después de ocurrido un sismo. Para la determinación de las ecuaciones de atenuación se definió el modelo matemático a considerar, las fuentes generadoras y los parámetros a relacionar para estimar la intensidad, fue necesario completar los registros digitales de reportes de intensidad puntuales y mapas de isosistas; obteniéndose una ecuación para los sismos generados por la subducción y otra para los sismos generados en la cadena volcánica. Así, incorporando al Sistema de Información de Geográfica de forma sistemática los parámetros físicos de un sismo y a través de un procesamiento geográfico automático se identifica la localización y se estiman las intensidades para las ciudades cercanas al epicentro y la ciudad capital, distribuyéndose la información de forma a través del sitio web institucional, e-mail, fax, SMS). Continuar con el análisis geográfico y geoestadístico permitiría obtener mapas de distribución continua de intensidades y comparar con los registros de aceleración, velocidad y desplazamiento del terreno; y así poder dar una mejor idea de la distribución de las zonas más afectadas después de ocurrido un sismo.

References : Musson, R (2005) Intensity Atenuation in the U.K., Journal of Seismology 9: 73-86

Erosion history of the southern Brazilian Shield as seen from detrital zircon U-Pb age patterns of sedimentary rocks of northwest Argentina.

Miller H , Adams Ch 2

1 Department of Geo- and Environmental Sciences, LMU München, Germany, h.miller@lmu.de
2 GNS Science, Private Bag 1930, Dunedin, New Zealand

Detrital zircons are mostly used for determining maximum ages of sedimentary or metasedimentary rocks, and for defining their provenance areas. Thus, changes of zircon spectra with time may also shed light to the history of possible provenance areas.

Our zircon spectra (Adams et al., 2008, and unpublished data) and data from literature of northwest and central Argentina show rock building, exhumation and erosion times for the provenance areas from about 2200 to 450 Ma. How did erosion areas and transport routes and styles change during that time?

The oldest maximum age of zircons of one sample of the Puncoviscana Formation (Humahuaca Valley) is 900 Ma. No younger individual zircons are here present at all, but a peak at 1000 to 900 Ma is evident. Most other samples of the Puncoviscana Fm. and their southern and southeastern metamorphic equivalents can be summarized in two groups: An older group shows peaks from 650 to 550 Ma and from 1050 to 900 Ma. Older zircons are present, but rare. A younger group is characterized by very young and sharp maxima from 535 to 525 Ma; ages around 1000 Ma are rare here. Older, Paleoproterozoic ages are rare in all samples. They concentrate around 2000 to 1800 Ma. These data are confirmed by many authors from the metamorphic equivalents of the classic Puncoviscana Formation in the Eastern Sierras Pampeanas. We cite:

- Sierra de San Luis: Maxima at 587, 631, 982 Ma (Steenken et al., 2008)
- Sierras de Córdoba: Maxima at 700-600, 1100-900 Ma (Escayola et al., 2007)
- Sierras de Córdoba: Maxima at 700-600, 1050-950 Ma (Schwartz & Gromet, 2004)
- Sierra de Ancasti: Maxima at 680-570, 1020-960, 2040-1850 Ma (Rapela et al. 2007)

After the Mid Cambrian Tilcarian orogeny, the late Mid to late Late Cambrian Mesón Group formed a molasse type trough separated from the Puncoviscana Fm. by a strong angular unconformity. Detrital zircons of polymodal late Neoproterozoic – Early Cambrian ages are identical with those of the Puncoviscana Fm. But, in contrast to the Puncoviscana Formation sediments, zircons of 1200-1000 Ma are scarce. That means that the Sunsás orogen had lost its former importance as a widespread high mountain range simultaneously active with the Brasiliano orogens. Characteristically, Paleoproterozoic zircons are rare, but if present, they concen-

trate from 2200 to 2000 Ma, different from the mostly 2000 to 1800 Ma old zircons of the Puncoviscana Formation. Such ages are very common and distinctly confined in the Río de la Plata craton, exposed in western Uruguay today, but continuing in subsurface to the west as far as the eastern limit of the "Pampean" Sierras de Córdoba (Rapela et al., 2007). Nevertheless, these mountains did not interfere with rivers which continued transporting the Brasiliano orogen debris.

Only slightly younger than the Mesón Group are the sediments of the Casa Colorada Formation (latest Upper Cambrian to Early Ordovician) in Quebrada de Humahuaca, Jujuy province (Di Cunzolo & Pimentel, 2008). Zircons show a clear maximum at 700 to 600 Ma. These may be recycled crystals of the Puncoviscana Formation, but as most of the other grains scatter around many older ages, it is more probable that the very well expressed maxima of late Neoproterozoic age relate directly to sources in the Brasiliano orogens. One of the described sections shows a distinctive maximum from 2200 to 2000 Ma: a hint of currents coming from Río de la Plata craton hills in the southeast.

For an outcrop of the Upper Cambrian-Lower Ordovician (?) La Cébila Formation (Catamarca and La Rioja provinces) Finney et al. (2003) described a group of 720 – 480 Ma old zircons. A characteristic peak at 600 Ma shows the ongoing provenance of sediments from the Brasiliano orogen, and similarly, the peak at 1200 Ma, from the Sunsás orogen.

Conclusions: Before the Late Neoproterozoic Brasiliano orogen formed and developed to a mountain chain, the Mesoproterozoic Sunsás orogen was the prominent morphological feature of the Brazilian Shield. It partly continued to be a mountain range even after the formation of the Brasiliano orogen and the building of the Brasiliano "Cordilleras". With the closure of the Adamastor Ocean, the rising Brasiliano mountain ranges exposed at first, old Neoproterozoic, and then later, continuously younger Late Neoproterozoic rocks in different parts of the orogen. Transport to the east was inhibited by the closure of the Adamastor ocean, the rising orogen itself and the formation of the Gondwana Supercontinent. So, river direction at the Adamastor suture changed definitely to the west where the paleo-Pacific ocean existed. The influence of the Sunsás orogen to sedimentation in the Andean basement was decreasing with time, due to partial cover by Late Neoproterozoic and Early Cambrian sediments.

After the mid-Cambrian a new sediment source appeared east of the Sierras Pampeanas, the Río de la Plata craton. Being as old as 2000 Ma, it probably was not a high mountain chain, but rather a hilly area, presenting enough relief for being exposed to erosion.

References

Adams CJ, Miller H, Toselli AJ, Griffin WL (2008) The Puncoviscana Formation of northwest Argentina: U-Pb geochronology of detrital zircons and Rb-Sr

metamorphic ages and their bearing on its stratigraphic age, sediment provenance and tectonic setting. N Jb Geol Paläont Abh 247/3: 341-352

DiCunzolo S, Pimentel M (2008) LA-ICPMS U-Pb provenance data for detrital zircons of Cambro-Ordovician units of the Quebrada de Humahuaca, Jujuy province, Argentina: Tectonic significance. In: Linares E, Cabaleri NG, DoCampo MD, Ducós EI, Panarello HO (compilers). VI South Amer Symp Isotope Geol Proc CD ROM Ext abstr 5 Buenos Aires ISSN 1851-6963: 3 pp.

Escayola MP, Pimental MM, Armstrong R (2007) Neoproterozoic backarc basin: Sensitive high-resolution ion microprobe U-Pb and Sm-Nd isotopic evidence from the Eastern Pampean Ranges, Argentina. Geology 35: 495-498

Finney S, Gleason J, Gehrels G, Peralta S, Aceñolaza G (2003) Early Gondwana connection for the Argentina Precordillera terrane. Earth Plant Sci Lett 205: 349-359

Rapela CW, Pankhurst RJ, Casquet C, Fanning CM, Baldo EG, González-Casado JM, Galindo C, Dahlquist J (2007) The Rio de la Plata craton and the assembly of SW Gondwana. Earth Sci Rev 83: 49-82

Schwartz JJ, Gromet LP (2004) Provenance of a late Proterozoic-early Cambrian basin, Sierras de Córdoba, Argentina. Precambrian Res 129: 1-21

Steenken A, López de Luchi MG, Drobe M; Siegesmund S, Kleinhans I, Wemmer K (2008) Are the banded schists of the Eastern Pampean Ranges comparable with the Puncoviscana Formation (central and northwestern Argentina)? In: Linares E, Cabaleri NG, DoCampo MD, Ducós EI, Panarello HO (compilers). VI South Amer Symp Isotope Geol Proc CD ROM Ext abstr 5 Buenos Aires ISSN 1851-6963: 4 pp

---

Avaliacao da vulnerabilidade quimica dos solos de area carstica de Minas Gerais - Brazil a contaminacao por cromo

Moraes AF de 1, Horn AH 2, Pereira AAG 3, Baggio H 4

1 Fundação Estadual de Meio Ambiente, Gerência de Gestão da Qual. do Solo (GESOL), Belo Horizonte - Brasil

2 Universidade Federal de Minas Gerais, Inst. de Geociências (IGC-NGqA), Belo Horizonte, Brasil hahorn@ufmg.br

3 Fundação Estadual de Meio Ambiente, Gerência de Geoprocessamento e Monitoramento (GEMOG), Belo Horizonte – Brasil

4 UNIMONTES – CAMPUS Pirapora

The studies were executed in a pilot area of 15 km² (5 Km E-W and 3 Km N-S) in the southern part of the hydrographic basin of the San Francisco River in Minas Gerais, Brazil. In this area are found several human activities among them limestone mining, cement production, calcination and farming. A part of the study area

is in carstic unit with rocks of high hydraulic permeability (Borghetti, 2002) which can cause a high natural environmental vulnerability. There the heavy metals interact in different ways, and with variable forces over the representatives chemical retainers (organic matter and oxides of iron, manganese and aluminum) in the their existent soils (Ianhez, 2003). This needs to be considered in the elaboration of calculation and function models of the chemical vulnerability of the soils, together with the influence of all the percentile of each chemical representative's retention and the inherent concentration of this component. Based on these suppositions, this work presents the chemical vulnerability model of the soils of the region for the metal chrome as well as the concentration of this metal in the study area.

The chemical vulnerability was calculated using the model presented after:

$$V_u = (pCTC/fCTC)xCTC + (pMO/fMO)xMO + (pO/fO)xO$$

V_u:	chemical vulnerability	P:	percentile of retention
F:	retention force	CTC:	capacity of cationic change
MO:	tenor of organic matter	O:	tenor of oxides

After collecting the samples in the study area, they were prepared and analyzed in the laboratories of UFMG and UFV using usual proceedings of EMBRAPA (Embrapa, 1997) and treatments contained in procedures of optimized analysis (Egreja Filho, 1997). The mathematical-statistical manipulations were done with ArcGis 9.2 and executed at the geoprocessing laboratory of GEMOG - FEAM. The percentile component of retention was obtained using the fractionation-distribution graph of the empirical determined chrome concentrations in the representative chemical minerals of the investigated soils.

Results: The isothere map of chrome in the soils indicates that the guiding values of CETESB were passed by Cr-content in the investigated soils samples (Cetesb, 2005). This demands a considerable attention in the land use of the area. As it was expected, larger concentrations of oxides, organic matter and values of CTC happened in areas with lower altitude due to higher deposition of fine materials originating from the intemperism processes, transport and deposition of materials in suspension. Consequently, the smallest chemical vulnerabilities for chrome happen in areas of deposition of fine materials, which can retain more heavy metals.

Conclusions and Suggestions: The use of chemical vulnerability maps are therefore an excellent mechanism of environmental and land use administration. However, their results always should be seen and appraised together with other existent factors like biological, physical and social ones to obtain the global vulnerability. The important result and contribution of this work was the obtaining of applicable information using the vulnerability in the example of the chrome, considering the chemical representatives of the soils that indeed keeps him/it as well as the use of the force of this retention.

References

Borghetti, C. A 2002. Influência da Indústria Calcinadora na Distribuição e na Concentração de Metais Pesados na Região de Córrego Fundo – Pains (MG). Dissertação de Mestrado. UFMG. Belo Horizonte. 71 p.

Cetesb. 2005. Decisão de diretoria Nº 195-2005-E, de 23 de novembro de 2005. São Paulo, CETESB. 4 p.

Egreja Filho, F. B. 1997. Extração seqüencial de metais pesados em solos altamente intemperizados: Utilização de componentes-modelos e planejamentos com misturas ternárias na otimização do método. Tese (Doutorado). UFV. Viçosa. 287 p.

Embrapa-Centro Nacional de Pesquisas de Solos. 1997. Manual de Métodos de Análise de Solo. Centro Nacional de Pesquisas de Solos - 2 ed. rev. atual. - Rio de Janeiro. 212 p.

Ianhez, R. 2003. Fracionamento Químico de Metais Pesados em Solos Contaminados por Resíduos Industriais e Otimização Quimométrica de Misturas para a Descontaminação por Lixiviação Química. Dissertação de Mestrado. UFMG/ICEX/DQ. Belo Horizonte. 158 p.

Use of Geographical Information Systems (GIS) in analyzing volcanic gas emissions on the environment at Poás Volcano, Costa Rica

Morales-Simfors N, Sivertun Å, Haraldson J

GIS-Lab/University of Linköping, Sweden

The use of GIS in analyzing volcanic gas emission on the environment has been evaluated at Poás Volcano, Costa Rica. The data sets required during this study were collected during the eruptions of 1989-90, 1994, 1999 and they include geological, geochemical, land use/land cover, soils and socioeconomic data sets. The results show that GIS-technology could be a very successful tool for the analysis and modeling of the estimation of gas emissions. Spatial relationship between the volcano, topography, socioeconomic data and gas emission inventories may reveal various patterns that can help in the evaluation of appropriate control strategies in the studied area, but it is first necessary to improve the methods of field data collection, data compatibility and availability of data. The objectives are to develop techniques to better integrate monitoring data into a GIS and to test different methods and models for studying the events of 1989-1990, 1994, 1999 and how to represent these events by means of GIS technology. The project contributed to a more effective use of GIS-capabilities and visualization of volcanic gases at the Poás volcano. Lengthy time-series of data should be collected in several monitor-

ing stations covering relatively broad geographic areas, in order to be able to correlate the data and gain more information of the phenomena studied. New methods of data integration into a GIS could be helpful to model volcanic gas emission and their impact on the population. This could be a valuable way to improve warning systems in many countries of the world.

Inferences of Late Pliocene-Pleistocene rock avalanches clustering in the Central Andes (32º LS)

Moreiras SM

CONICET, IANIGLA (CCT). Unidad de Geomorfología. Av Ruiz Leal s/n. Parque Gral. San Martín. Ciudad. Mendoza (5500). Argentina. moreiras@mendoza-conicet.gov.ar

In the Argentinean Central Andes (at 32° 30´ S - 69° 20´ W) preserved huge Late Pliocene- Middle Pleistocene rock avalanches let to know about the behaviour of this extreme events, as well as, evidence the regional neotectonic activity.

The Tigre Dormido rock avalanche (TD) mobilised 1.7x10^9 m^3 of debris material with a velocity of 100 m/s (H/D 1.55). It ran off 10 km from the source area reaching the Mendoza river valley being dammed up and descended topographically 2,000 meters (H/D=0.22). Stratigraphic studies reveal the TD deposit, as well as, fine paleo-lake deposits were eroded by an outwash. Based on relative dating techniques (soil development, rock varnish development on blocks, weathering degree measured on dacite blocks) and topographic relations this drift was correlated with the Uspallata Glaciation. This cold period was assigned to at least Early Middle Pleistocene age as the corresponding terminal moraine is younger than an ash level dated by fission track 360±70 Ky (Espizúa, 1993).

The Placetas Amarillas rock avalanche (PA) covers an area of 7 km^2 with an estimated volume of 1.6x10^9 m^3. This event also shows two separate episodes and the ending debris flow ran 10 km (H/D=0.11) descending 2000 m topographically (Moreiras, 2005d, 2006b). This extraordinary event also generated a paleo-lake evidenced by a 38 m thick lacustrine sequence where layers of sands and silts are intercalated. Lower sediments are rich in organic matter, while relict diatomite levels are observed on the top of the lake sequence. Diatomite deposits, rich in carbonate and with a high content of volcanic glass, were analysed determining cosmopolitan species that do not indicate climate conditions (Moreiras, 2004b, 2005d, 2006b). Stratigraphically, this rock avalanche is overlain by three ash layers interbedded in alluvial fans. The middle level was dated by Ar^{39}/Ar^{40} method 350±80 Ky. Whereas, the Piedras Blancas rock avalanche (PB) had a volume ~9.6x10^8 m^3 and an H/D relation equal to 0.2. Dammed paleo-lake generated by

this event reached 30 m thick sequence of fine sediments with a maximum level of 2677 m a.s.l. that covered ~0.75 km^2.

Three greyish white volcanic deposits interbedded in alluvial fans overlaid, as well, the PB deposit and associated paleo-lake sequence. The middle ash level could be correlated by geochemistry analyses with the previously dated 350±80 Ky located 4 km far (Moreiras, 2006c). Besides, teeth material of an old horse was found in the impounded paleo-lake related to the PB. The mammal specie was identified as *Hippidion devillei* that lived in South America from Upper Pliocene to Upper Pleistocene when it then became extinct (Cerdeño et al, 2009).

Due to clustering of these extraordinary paleo-events and according to involved rock avalanche volumes, a simultaneous seismic triggering mechanism with magnitude >6 is proposed. Field observations match with this assumption. Although hesitated liquefaction structures were recognised in the lake sequence related to PB, disconnected lake outcroppings appear strongly folded. Hence, this work's findings extend the paleo-seismicity of this region being affected historically by Ms>7 earthquakes linked to the Nazca Plate flat-slab subduction at this latitude. Thus, Quaternary activity of regional faults is suggested as generally liquefaction features and folds are associated with nearby seismic source. Nevertheless, forcing paleo-climate conditions are not underestimated. Even through evidences of local warm period is lacking, rock avalanches are previous to a glacial period and the existence of paleo-lakes suggests a humid period. Thus, horse's rests may implicate that this areas were non-glaciated during this period at this altitude (2650 m a.s.l.). Future effort in numerical dating and regional paleo-climate proxies are required.

References

Cerdeño E., Moreiras S.M., Alberti M.T.(2009) Primer registro de Hippidion (Equidae, Perissodactyla) en el Cenozoico superior de la Cordillera de Mendoza, Argentina. Revista del Museo de Ciencias Naturales (*in press*)

Espizúa L.E. (1993) Quaternary Glaciations in the Rio Mendoza Valley, Argentine Andes. Quaternary Research 40: 150-162

Moreiras, S.M.(2004) Zonificación de peligrosidad y riesgo de procesos de remoción en masa en el valle del Río Mendoza. PhD. thesis. Facultad de Ciencias Exactas, Físicas y Naturales. Universidad Nacional de San Juan. Argentina

Moreiras, S.M.(2005) Geomorphological survey of the Placetas Amarillas rock avalanche, Cordon del Plata (Central Andes), Mendoza province - Argentina. Proc. of Sixth International Conference on Geomorphology, Zaragoza, 137

Moreiras, S.M.(2006) Chronology of a Pleistocene rock avalanche probable linked to neotectonic, Cordon del Plata (Central Andes), Mendoza - Argentina. Quaternary International 148, 138-148

Spectral analysis of geophysical logs from the Cerrejon Formation, Colombia

Morón S 1, Montes C 1, Jaramillo C 1, Bayona G 2, Sánchez C 3

1 Smithsonian Tropical Research Institute, morons@si.edu
2 Corporación Geológica ARES
3 Department of Geosciences, Universidad Nacional de Colombia.

The Cerrejon Formation exhibits a characteristically repetitive and monotonous stacking pattern. It has a stratigraphic thickness of about 1000 m and a strike-length of at least 30 km through Cesar - Ranchería Valley. Fourier analysis of stratigraphic proxies (gamma ray, density and resistivity logs) were used to evaluate the possibility of orbital forcing in the Cerrejon Formation. Analysis of different lithologies indicate compaction ratios of 0.44 for sandstone, 0.51 for siltstone, 0.5 for sandy siltstone, meaning that the compaction relationship is 1:1.26, 1:1.95 and 1:1.99 respectively. Coal compaction relationship was evaluated as 1:4.5. Finally the weighted average for the entire column was 0.45. The spectral analysis results, expressed as time, suggest a eccentricity influence using the gamma ray log (cycles of 135m equivalent to 121608 years) and precession (cycles of 23 m equivalent to 21086 years) for resistivity data. Additional frequencies were obtained, that could be linked to small order cycles, parasequences and/or autocyclic processes.

Miocene Cucaracha Formation in Panama, climatic or tectonic event?

Morón S 1, Montes C 1, Cardona A 1, Valencia V 2, Farris D 3, Rodriguez I 1 Jaramllo C 1

1 Smithsonian Tropical Research Institute, morons@si.edu
2 Department of Geosciences, University of Arizona
3 Department of Geosciences, University of Florida

The Early and middle Miocene Cucaracha-Culebra Formations are preserved within a narrow basin located in the Panama Canal area that is significant as it contains the record of the southwesternmost Caribbean paleogeography during Miocene times. The Culebra Formation consists of black mudstone changing upwards to coarsening-upward sequences of sandstone consisting of quartz, reworked fragment fossils and highly instable components such as plagioclase and volcanic lithics. The Cucaracha Formation consists of conglomerate composed by aphanitic volcanic clasts with sizes no bigger than pebble, interbedded with greenish and reddish mudstone representing paleosols. The combined thickness of the Culebra and Cucaracha Formations is less than 200 meters, and their contact is

abrupt and easily recognizable by the coloration change. This change also represents a shift from marine to continental environments in a prograding system that could also record a change in subsidence regimes. Detailed stratigraphy, XRD clay mineralogy (20 samples) and sandstone modal analyses have been carried out to understand the origin of this abrupt change in the basin. Significant intensities of Montmorillonite and Vermiculite were found as well as low intensities of Kaolinite and Chorite suggest the idea that the source area remained the same during the Miocene. U/Pb detrital zircon analyses from both formations present major age distribution peaks at 20, 33 and 55 Ma related to the erosion of both plutonic and volcanic sources. Fabric elements show that normal faults dipping to the south and southeast were active during early Miocene times, creating the accommodation space for the Culebra and Cucaracha Formations. Later alkalic magmatism activity -common in extensional environments- in the same basin probably used the preexisting structures to reach the surface. These units therefore document sedimentation within a volcanic arc that was being locally disrupted by transtensional faulting probably related to the initial stages of the oblique collision with northwestern South America.

Cenozoic marine invertebrates of Chile: state of the art exemplified by mollusks

Nielsen SN

Inst. f. Geowissenschaften, Christian-Albrechts-Universität zu Kiel, Ludewig-Meyn-Str. 10, 24118 Kiel, Germany. nielsen@gpi.uni-kiel.de

Mollusks are the best known group of marine invertebrates from the Chilean Cenozoic. With Darwin's (1846) first collection we got a glimpse, with Philippi's (1887) monograph we thought we knew most about the Cenozoic fauna of Chile. However, ongoing work since the 1980's shows that we are far from really knowing the faunas, faunal changes, and their environmental implications. Before Philippi, 88 mollusk species were named from the Chilean Cenozoic (see Griffin & Nielsen 2008). Philippi (1887) multiplied this number by naming additional 120 gastropods, 220 bivalves, 3 cephalopods, 5 scaphopods, and 2 chitons. Work since the 20th century mainly consolidated these results; synonymising some species, adding information on existing ones, and describing additional species.

At the moment we have a fairly good overview of the early Miocene Navidad fauna reaching as far south as the Chonos Archipelago, although roughly 100 species in new collections remain undescribed. However, much less is known about younger faunas of that whole area. Further south, work on the fauna from Golfo Tres Montes has only begun. The Neogene faunas from the areas around Co-

quimbo, Caldera and Mejillones have not been reviewed since Herm (1969) and reasonable comparison with Peruvian faunas, like for the Navidad fauna, is difficult until this has been done. Even smaller is our knowledge of Eocene faunas, apparently only present at Algarrobo and on Arauco (Philippi 1887). But Tavera's works are taxonomically difficult and for many of Philippi's species it is not known where exactly they come from and what age they have. Even basics like geologic mapping of formations and stratigraphy are not sufficient for most formations. Much confusion still exists, e.g., regarding the Arauco Eocene and Paleocene and Oligocene deposits have not been unequivocally accounted for.

So, since most localities and faunas are not or poorly dated and many faunas remain poorly known, not much can currently be said about timing and magnitude of faunal changes, latitudinal migration, direction of dispersal and species origination and extinction. This means that apart from taxonomic work also much other data has to be generated in an interdisciplinary effort before we can tackle the important questions in modern science which can also attract a broader scientific audience and the general public.

References

Darwin C (1846) Geological observations on South America. Smith, Elder & Co, London, 279 p

Griffin M, Nielsen SN (2008) A revision of the type specimens of Tertiary molluscs from Chile and Argentina described by d'Orbigny (1842), Sowerby (1846) and Hupé (1854). J Syst Palaeont 6: 251-316

Herm D (1969) Marines Pliozän und Pleistozän in Nord- und Mittel-Chile unter besonderer Berücksichtigung der Entwicklung der Mollusken-Faunen. Zitteliana 2, 159 p

Philippi RA (1887) Die tertiären und quartären Versteinerungen Chiles. FA Brockhaus, Leipzig, 266 p

---

Mineral Pigments from Minas Gerais – Brazil. Part III: Application to Producing Paints

Oliveira JAS 1, Saturnino JO 1, Sousa, OM 2, Moresi CMD 1, Souza JSB 1

1 Universidade Federal de Minas Gerais, juliana@qui.ufmg.br
2 Escola M. Luiz Gatti

Since ancient times natural mineral pigments have been utilized, as they are easily found and widely used for coloring materials in Arts and artifacts. Minas Gerais (MG) State, Brazil is composed of great geological variety. When extracted directly from the soil, the pigments present different colors, like yellow achres, red earths,

green earths, dark yellow or brown siennas and umbers. Sometimes these can be seen where the rocks are cut and roads built. Sorrounding Belo Horizonte, the main city of Minas Gerais, these pigments are mainly associated with the Nova Lima group, composed of sedimentary and metamorphic rocks. In order to better understand the pigments compositions and applications, a research group involved in geo-science, chemistry and Arts has been working in this subject.

The present work deals with a group of pigments collected near Belo Horizonte, in Itabirito, MG: red, ochre, light pink, light green and pale yellow. The fine granulometry powder compounds were characterized by X-ray diffraction and fluorescence, showing kaolinite, illite, hematite and goethite as main minerals. After being collected, the samples were cleaned, dried, ground, classified after the grain size and stored. The granulometric fractions were applied to producing paints like water color, acrylic, guache and wall paint for architectural and handcraft purposes.

The developed tests showed suitable hiding capacity and good dispersion in some solvents.

Ichthyosaurs from Torres del Paine National Park, Southernmost Chile

Pardo Pérez J 1, Stinnesbeck W 1, Salazar Soto C 1), Leppe Cartes M 2, Frey E 3

1 *Inst. f. Geowissenschaften, Universität Heidelberg, Im Neuenheimer Feld 234-236, 69221 Heidelberg, jpardo@geos.uni-heidelberg.de*

2 *Instituto Antártico Chileno, Punta Arenas, Chile*

3 *Staatliches Museum für Naturkunde Karlsruhe (SMNK), Erbprinzenst. 13, 76133 Karlsruhe*

In the year 2003, Shultz et al. reported the presence of a fragmentary ichthyosaur skeleton in the Torres del Paine National Park in southern Chile. This find occurred in a large erratic block in glacio-fluvial sediments, adjacent to the Southern Patagonian Ice Field, and extended the distribution of ichthyosaurs some 1500 – 2000 km south of ichthyosaur material previously reported from the Neuquen basin in Argentina (e.g., Gasparini & Fernandez, 1997). In the years 2004 and 2005, however, expeditions to the area organized by glaciologists of the Universidad de Magallanes in Punta Arenas, located an outcrop area approximately 1 km to the east of the Shultz et al (2003) locality, where sediments similar to the isolated block contain numerous articulated ichthyosaur skeletons aligned with fragmentary material. These Torres del Paine National Park ichthyosaurs represent the southernmost occurrence of this group yet discovered in South America. At present, specimens are exposed to weathering and the fossil deposit and its faunal assemblage are virtually unknown.

In approximately one week of fieldwork in 2007, we discovered and relocated 15 completely or semi-articulated specimens of Ophtalmosauridae, including complete crania with teeth, vertebral columns with the tail bend preserved to the tiny terminal vertebrae, articulated flippers, girdles and thoracic elements. In addition, primary fragments (e.g., vertebrae, ribs, isolated mandible) are abundant. The specimens reach a maximum length of 4.5 m, but most are between 3 and 4 m long. At least two juveniles were discovered with an approximate lenght of 50 cm. The bones are black and thus easily recognized in the grey sandstone. Because all surfaces are polished by the retreating glacier, bones exposed on these surfaces are polished, too. But in most cases, large parts of the specimens are still embedded and preserved in three dimensions. Our inicial on site analysis assigns the specimens to *Platypterygius* Von Huene, 1922 and *cf. Caypullisaurus* Fernández 1997. Regional geology and ammonites associated to the ichthyosaurs suggest that the assemblage is Hauterivian-Barremian in age.

References

Fernández, M. (2001) Dorsal or ventral? Homologies of the forefin of *Caypullisaurus* (Ichthyosauria: Ophthalmosauria). Journal of Vertebrate Paleontology. 21 (3): 515-520.

Motani, R. (1999) On the evolution and homologies of ichthyopterygian forefins. Journal of Vertebrate Paleontology. 19 (1):28- 41.

Pardo, J. (2006) Análisis de registro de reptiles marinos cretácicos (reptilia: ichthyosauria) en áreas periglaciadas del Parque Nacional Torres del Paine. *Inédito*, Title work to obtain the academic degree of Licenciada en Ciencias Biológicas. Facultad de Ciencias, Departamento de Ciencias y Recursos Naturales, Universidad de Magallanes.

Shultz, M.; Fildani, A; Suárez, M. (2003) Occurrence of the Southernmost South American Ichthyosaur (Middle Jurassic-Lower Cretaceous), Parque Nacional Torres del Paine, Patagonia, Southernmost, Chile. *Palaios*, 18: 69-73

Wilson, T. (1991) Transition from back-arc to foreland basin development in the southernmost Andes: Stratigraphic record from the Ultima Esperanza District, Chile. Geological Society of America Bulletin. 103, 98-111. 15 figs.

$\delta^{18}O$ and $\delta^{2}H$ in Antarctic water precipitations. A discussion about tendencies

Parica C A

Universidad Nacional de General San Martín-CONICET, Argentina, cparica@unsam.edu.ar

Isotopic analyses by $\delta^{18}O$ and $\delta^{2}H$ in different places of Antarctica were carried out (Parica, 2008). Argentine Stations like Cámara at Half Moon Island and Jubany (25 de Mayo Island-King George Island) in the environment of the South Shetland Islands, Vernadski (Ukrania, ex british Faraday Station) in the western coast of the Antarctic Peninsula, Rothera (British Station) at Margarite Bay and Halley Bay at the southernmost of the Weddell Sea. Data from Half Moon Island and Jubany belong to the Argentine Antarctic Research Program and data from Vernadsky, Rothera and Halley Bay belong to the GNIP´s Program of the IAEA. For the different localities there are different periods in the time of collection.

Half Moon Island. Water collected in two summer antarctic campaigns, this collection let to build a Local Meteoric Water Line, which is very close to WMWL (World Meteoric Water Line). The rank of temperatures established by ^{18}O shows a different origin for the clouds, in a northern position than the South Shetlands, generated in the South Pacific or Drake Passage.

Jubany Station. There is a good record for four years all the year. These data shows some influence of the sea, may be diffusion meanwhile precipitation because the effect of the sea vapour. As Half Moon Island isotopic data for oxygen show a northern origin of the clouds.

Vernadsky is located in the western side of Antarctic Peninsula, this is the ex British Faraday Station. There is very good record since 1964, and data were analyzed until 2004. The Local Meteoric Water Line shows a good agreement with WMWL, a small separation is the result of diffusion effects meanwhile precipitation. Analyzing data in the time can be observed an increasing tendency in $\delta^{18}O$ and $\delta^{2}H$ consequence of increasing temperatures.

Rothera (67° 34' 12" S-68° 7' 48" W). Isotopic data is indicative of a strong local incidence with evaporation phenomena. Means of annual isotopic data along the year an increasing in values in March, according clouds formation in the southern summertime. In winter, the lowest values for $\delta^{18}O$ and $\delta^{2}H$ are consistent with the lowest temperatures in Antarctica.

Halley Bay (75º 34' 60" S y 20º 34' 00" W). Located in the southernmost of the Weddell Sea. This is one of the most interesting topics to analyze. There are data since 1964, the Local Meteoric Water Line is the closest to WMWL, just a small difference in d (Deuterium excess). Anyway the tendency obtained from $\delta^{18}O$ and $\delta^{2}H$ also in temperatures is decreasing.

Taking in account all data there are not a definite conclusion, data obtained on the western side of the Antarctic Peninsula agree a growing tendency not only in

$\delta^{18}O$ and $\delta^{2}H$, and also temperatures grow in time. Meanwhile data from the southernmost of the Weddell Sea, like the obtained from Halley Bay Station, denote a decreasing tendency in $\delta^{18}O$ and $\delta^{2}H$ and temperatures.

Another decreasing tendency in temperatures for Antarctica is the Taylor Dome, where a profile representative of the last 150.000 years has a slight decreasing tendency too. Different places different tendencies based on isotope data should be the main conclusion for the spread of localities analyzed in the Antarctic Territory. It is relevant to get more data in the time to have a good accuracy in the tendencies, small samples for statistics is not the best way to define conclusions mainly along the time.

References.

Parica C A (2008) Análisis de Variables Ambientales en el Territorio Antártico. Ph. D. Thesis. Universidad Nacional de General San Martín, Provincia de Buenos Aires, Argentina. Unpublished. 241 pp.

Destroying a myth: Non drinkable water in Antarctic Stations

Parica CA 1, Remesal MB 2, Salani FM 2, Rinaldi CA 1

1 Universidad Nacional de General San Martín-CONICET cparica@unsam.edu.ar
2 Universidad Nacional de Buenos Aires-CONICET

Pollution in antarctic water was not seriously considered, mainly attending natural sources of contaminants. After Parica & D'Ascanio (1993) analyzing the problem at the Argentine Station "Esperanza", located at Hope in the northernmost of the Antarctic Peninsula. A second station was analyzed at Danco Coast, "Primavera Station", partially mentioned by Parica and Remesal (2005 a-b).In both cases the chemistry of the water shows acid pH, and high contents of nitrates and nitrites.
Esperanza Station: This Antarctic station gets the water from the Boeckella lagoon, which is resourced by several streams from ice melting originated in the Depot Glacier. The water streams cross one of the most important penguin colonies in Antarctica (close to one million birds) where the products of the organic activity of the penguins are incorporated to the water.
Features as NO_3^- and pH are out of the accepted values recommended by the WHO (World Health Organization) (25 mg/l for nitrates and 6.5 for pH), and the presence of nitrites are absolutely forbidden, making the water as NON DRINKABLE. The origin of these anomalous values has the place in the penguin colony. Some solutions were proposed to solve this problem with the water resource.
Anyway the best solution proposed to have drinkable water in the station according temperatures distance to the station buildings and volume of water is the desalinization.

Chemical analyses:

Colour	uncoloured
Turbidity	absent (in labs).
pH	4.2
Dissolved solids	129 mg/l
(CO_3Ca) (as hardness)	4 mg/l
Cl^-	0.5 mg/l
$SO_4^=$	22 mg/l
NH_4^-	3.1 mg/l
NO_2^-	0.35 mg/l
NO_3^-	151 mg/l

Because the process of desalinization could be expensive it should be recommendable to have to different lines of water, one, the oldest from the Boeckella lagoon for normal house appliances and the second one for human consumption.

Primavera Station: This temporary station is located at Danco Coast, the provision of water has place in a special small dike where some streams coming from the penguin colony way in. The chemical analyses for three different streams demonstrate that the worst is the used for human consumption in the station. This stream has the advantage of the gravity, which is directly connected to the water tanks of the main buildings of the station.

Chemical analyses

Sample	PRA-1	PRA-5	PRA-8
Na^+	0,3	0,3	0,3
K^+	1,3	1,7	2,3
Ca^{++}	29,6	29,4	35,3
Mg^{++}	1,7	1	2,2
Cl^-	7,2	8	8
$SO_4^=$	19,2	15	28,8
$CO_3^=$	ND	ND	ND
HCO_3^-	15,8	47,5	15,8
NO_3^-	48,8	16,1	58,7
Cond	0,18	0,12	0,19
PH	4,8	7,8	5,7

The PRA-1 is the stream actually the source of water for the station with high nitrates content and acid pH (4.8); the PRA-1 stream shows better chemical features for human uses.

In fact the water on use for the station is NON DRINKABLE (PRA-1). The solution for this summer station is relatively simple; it is necessary to change the source, just pumping water from the PRA-1 stream with better quality, DRINKABLE water in this case.

The fact observed for these two Argentine Stations established new paradigms about the water in Antarctica; in a first overview is distinguishable that the problem has a natural origin, located in the own environment features, the man is not responsible for the problem but it is responsible for a wrong choice in the source of water for human uses.

References.

Parica C A (2008) Análisis de Variables Ambientales en el Territorio Antártico. Ph. D. Thesis. Universidad Nacional de General San Martín, Provincia de Buenos Aires, Argentina. Unpublished. 241 pp.

Parica C A, D'Ascanio C (1993) Calidad del agua de consumo de la Base Antártica Esperanza. Segundas Jornadas de Comunicaciones sobre investigaciones Antárticas. Buenos Aires, 11 al 14 de noviembre de 1991.

Parica C A, Remesal M B (2005a) Geología del área de la Base Primavera-Refugio Cobbett, Bahía Hughes, Antártida. Vº Simposio argentino y Iº internacional sobre Investigaciones Antárticas. Edición electrónica. CD.

Parica C A, Remesal M B (2005b). El ciclo hidrológico y quimismo del agua de la zona de la Base Primavera. Vº Simposio argentino y Iº internacional sobre Investigaciones Antárticas. Soporte electrónico. CD.

The iceberg A22A. The evolution of δ^2H and $\delta^{18}O$ in the upper levels and drifting in the Weddell Sea after the break-up.

Parica C

Universidad Nacional de General San Martín, cparica@unsam.edu.ar

Meanwhile the Summer Antarctic Campaign 2006-2007 an ice core from the iceberg A22A was sampled. This iceberg is now drifting in the Weddell Sea after the break-up in 2000 from the Ronne Ice Shelf at the southernmost of the Weddell Sea. The Project AMIGOS was performed by researchers from the Argentine Antarctic Institute (IAA) and The National Snow and Ice Data Center (University of Colorado). The main purpose of the project at the very beginning was the observation in real time of meteorological variables and following the drifting of this mega iceberg. As a proposal of this author an ice core was taken 10.5 meters length, representative according calculations of snow deposits of the last 42 years. The main target with the analyse of the ice core by isotopic techniques is the observation of the climate evolution and to appreciate variations in the isotopic ratios after the break-up in the year 2000.

The ice core was transported in the freezer of the Argentine Ice breaker Admiral Irizar to Buenos Aires for the analytical treatment. In this way the fractionation of the ice core was developed in the cold labs of the CEITOX (Centre for Toxicology Research) and the isotopic analyses were developed at INGEIS (Institute for Geo-

chronology and Isotopic Geology). Oxygen analyses were processed according the techniques proposed by Panarello & Parica (1984) and Hydrogen according Coleman *et al.* (1982) and modifications by Florkowski & Rogovic (1983), Hayes & Johnson (1988) and Schimmelmann & De Niro (1993).

The ice core could be divided into 12 thick slices for the analyses, level -1 to 0 meters the upper level, and the deepest -10 to -10.5 meters. From level -10 to level -3 isotopic data show cycles in δ^2H and $\delta^{18}O$ (-181‰ to -164‰ vs. V-SMOW for ^2H, and -23.7‰ to -21.3‰ vs. V-SMOW for ^{18}O), the values for oxygen are representative of mean temperatures for precipitations between -16.73 ºC as the lowest and -12.12ºC as the highest according Mook (2002) formula (TºC = ($\delta^{18}O$+15)/0.52).

A violent increase in the values of δ^2H (-156; -153 ‰) and $\delta^{18}O$ (-19.9; -19.8 ‰) can be observed after the break-up of the iceberg symptomatic of higher temperatures (-9.43; -9.23 ºC) at lower latitudes in the Weddell Sea. The local MWL (*World Meteoric Water Line*) is very close to the WMWL (*World Meteoric Water Line*), indicative of a short time between evaporation and precipitation, without diffusion phenomena meanwhile precipitation (Parica, 2008).

References

Coleman M L., Sheperd T J, Durham J J, Rouse J E, Moore F R (1982) A rapid and precise technique for reduction of water with Zinc for Hydrogen isotope analysis. Anal Chem. 54: 993-995.

Florkowski T, Rogovic B (1983) Hydrogen sample preparation for mass spectrometry (using zinc). International Atomic Energy Agency (IAEA), Isotope Hydrology Laboratory, Technical Procedure Note Nº 31.

Hayes J M, Johnson M W (1988) Regent and procedure for preparation of H_2 for hydrogen-isotopic analysis of water. Indiana University, Department of Geological Sciences. Internal Report. Non edited.

Mook W G (2000) Environmental isotopes in the hydrological cycle principles and applications. UNESCO/IAEA Series on Environmental Isotopes in the Hydrological Cycle Principles and Applications. Digital version (Portable Digital Format). 279 pp.

Panarello H O, Parica C A (1984) Determinación de la composición del oxígeno en aguas. Primeros valores en aguas de lluvia de Buenos Aires. Asoc. Geol. Arg. Rev., XXXIX (1-2), 3-11.

Parica, C.A., 2008. Análisis de variables ambientales en el Territorio Antártico. Ph.D. Thesis. Universidad Nacional de General San Martín. Provincia de Buenos Aires, Argentina. Unpublished. 241 pp.

Schimmelmann, A. y Deniro, M.J., 1993. Preparation of organic and water hydrogen for stable isotope analysis: effects due to reaction vessels and zinc reagent. Analytical Chemistry, 65: 789-792.

50 Years TMP – Transition from Small-Scale Artisanal Gold Mining to Large-Scale Corporate Mining in the Tapajós Mineral Province (TMP), Brazil – Potential and Needs

Peregovich B 1, Mathis A 2

1 UFPA – Universidade Federal do Pará, Marabá-PA, Brasil Peri@ufpa.br
2 NAEA / UFPA – Núcleo de Altos Estudos Amazônicos, Belém-PA, Brasil

After 50 years of intense exploitation of placer gold deposits, the Tapajós Mineral Province is facing a period of important transition. Most of these superficial deposits, easily to explore and mine with simple, primitive methods are nearly exhausted or unprofitable using artisanal methods. These secondary deposits however, are often related to primary occurrences. Both, high grade vein-hosted, and low grade disseminated style deposits have been discovered in recent years in the TMP. In the past ten years or so, several national and international mining companies have shown interest in exploring for, and mining primary gold deposits in the TMP – partly because the mineralized gold occurrences are reasonably well known as a result of past garimpeiro activity; and conversely because the Tapajós is virtually unexplored using modern prospecting methods. SERABI MINING PLC began exploring in the region in 2001, and was in 2008 producing about 100 kg of gold per month from the underground Palito Mine, utilizing modern sulphide-flotation and cyanide-leach technologies.

This studies aim at understanding and documenting the recent situation and the reality in the TMP, focusing on potential and needs as well as on impacts and benefits for the entire region. Historical analysis of production from various deposits as well as geological, mineralogical, structural and metallogenic studies of the TMP can help identify mineralized areas (small scale mines), which might be attractive targets for corporate gold mining. Social and public interest investigations will study and document the various forms of cooperation and / or contracts between traditional mine owners and mining companies and determine the utility, benefits, possible conflicts and consequences for ongoing small scale mining activities as well as for mining companies. Analyzing the roles of governmental organizations such as: CPRM; DNPM; IBAMA; SECTAM; SEICOM; SEMMA; and local government – as well as the roles of public / private associations and groups such as: AMOT; SIMIOESPA; SDG; IBRAM and the parts they play in the process under institutional and political aspects might lead to remove bureaucratic barriers and improve the relations with them for both garimpeiros and mining companies. Logistical and environmental affairs require to explore existing infrastructure (access to mining areas, transport, availability of food, fuel, tools, transport, goods, etc.) in order to recommend possible improvements as well as working out various prevention and remediation programs for impacted mining areas in order to restore damaged areas and prevent unnecessary harm to the environment.

Pso Yobai epithermal gold - Praguay

Pérez W, Benítez JC, Medina M

Latin American Minerals Paraguay S.A.

The Project is located in south eastern Paraguay, approximately 180 kilometers east of Asuncion, the capital of Paraguay. Paso Yobai is an emerging gold camp discovered by local prospectors in 1996.

Geologic setting: The regional geology consists of Permian sandstones intruded by mafic dykes related to a Cretaceous mafic alkaline complex located 20 kilometers east of Town Paso Yobai. The mafic dykes extend for several kilometers and vary from a few meters to more than twenty of meters wide. The extensive nature of the dykes is directly related to regional riftings which occurred during the separation of the African and South American continents.

Mineralization: Paso Yobai is a high-level low-sulfidation epithermal system related to alkalic rocks. Native gold is strikingly common in numerous very thin quartz-pyrite and quartz manganese veins and in parallel veins with calcite - marcasite near the contact of mafic dykes and the sandstones. Alteration is predominantly smectite, kaolinite, and less silicified zones, peripheral to the high grade mineralized vein-zones. The mineralized vein-zones range from one meter to over 20 meters wide and can be traced continuously for close to 8 kilometers. Representative grab sample from the mineralized vein-zones exposed in test pits along strike returned up to 100 grams per ton gold.





Paso Yobai - Work Completed to Date to Develop the Mineralized Zone
- 3000 Km Helicopter based Magnetic and Electromagnetic Survey
- 14,000 soil samples collected
- 2000 rock chip and channel chip samples
- 5236 m diamond drilling completed
- 100km Surface Survey High Resolution Mag
- 11 Big Trenches completed
- 637 Trench Chanel Samples

Conclusions
- Mineralization related to Carbonate and quartz veins
- Alteration Studies (PIMA) demonstrate gold is related to Smectite (i.e. low temperature, close to surface and pH neutral)
- There is a link to mafic alkalic magmas- hosted in Mafic Dykes
- Geochemical analysis of core and soils show that the gold is associated with: Mn, V, P, As, La and Se
- 66% of the gold in the ore is coarse and 44% is fine gold
- Up to 90% of the gold can be recovered by gravity from the ore body
- *"Paso Yobai is a opportunity to develop a new mining camp in South America"*

Characteristics of the phreatoplinian layers the Congo and Conacaste tephras (Coatepeque Caldera, El Salvador)

Pérez W , Freundt A , Kutterolf S

IFM-GEOMAR, Wischhofstr. 1-3, 24148 Kiel, Germany, wperez@ifm-geomar.de

The Coatepeque caldera in western El Salvador is a 11x7 km depression product of several violent and voluminous volcanic eruptions. The two younger ones resulted in the 53 ka Congo Tephra and the 51 ka Conacaste Tephra.

The Congo eruption occurred after a major volcanic break since the Arce Tephra eruption at 72 ka (Kutterolf et al., 2008a). Strong erosion during this period created a rough topography and steep gradients so the deposits slumped and slided locally during emplacement. Total volume of the Congo Tephra is ~51 km^3 (Kutterolf et al., 2008b). The deposit consists of a basal fallout sequence formed by 7 units (A-G). overlain by an alternation of two surge packages and two ignimbrites. The CCT erupted at 51 ka shortly after the Congo eruption; its tephra volume amounts to ~23 km^3 (Kutterolf et al., 2008a,b). This deposit has a very simple sequence with a lower fallout portion consisting of 4 units (A-D), with two well-sorted pumice lapilli layers sandwiching a thick fine tuff with abundant accretion-

ary lapilli. It nicely mantles the paleotopography and is overlain locally by surges and an ignimbrite.

The stratigraphic succession in the two deposits is very similar, although the Conacaste Tephra shows a simpler internal stratigraphy than the Congo Tephra. Both started with minor phreatomagmatic deposits, followed by a Plinian, a Phreatoplinian and another Plinian eruption, to end up with the generation of pyroclastic density currents forming surges and ignimbritic deposits.

Our work focuses in the study of the layers CGT-C and CCT-C because their characteristics like grain size, sorting, abundant accretionary lapilli and wide dispersion –similar to that of Plinian layers- suggest an origin by a Phreatoplinian eruption and compare them with typical Plinian layers below and above (CGT-B and CGT-D; CCT-B and CCT-D). Grain size analysis of the different layers show that the Plinian fall deposits of the Congo and Conacaste tephras are well sorted and coarser-grained, whereas the Phreatoplinian layers CGT-C and CCT-C are also well sorted but finer grained, with median values of $>3\phi$ plotting also in the field of fall deposits of Walker (1971). The skewness is positive for the fall deposits and negative for most of surge, ignimbrite and the phreatoplinian layers. This negative skewness has been also observed in other phreatoplinian deposits like the layer C of Askja. Such negative skewness reflects an overproportional fine tail of the distribution. The phreatoplinian fallouts are particularly rich in very fine ash (<0.063 mm) with 30-60 wt-%, in comparison with the well sorted Plinian fall units with 2-7 wt.% of very fine ash, which is still slightly higher than for other Plinian deposits.

Density and vesicularity distributions of pumice fragments through Congo and Conacaste deposits are in the range expected for felsic pumice from magmatic Plinian eruptions and as such give no direct evidence for the involvement of external water in the eruptions. In the light of the eruptive histories discussed above, however, the lower vesicularity of fallout CCT-B (bracketed by clearly water-influenced units A and C) can be attributed to water access to the conduit either causing premature fragmentation or hindering vesicle growth by cooling.

In both tephras, fragmentation occurred within the uppermost few hundred meters of the conduit. Water access at significantly greater depths would have at least partially quenched the magmas and be evident in reduced vesicularities, for which there is no evidence. The CCT eruption began with a phreatomagmatic opening phase and the first fall has somewhat reduced vesicularities, suggesting water contact at shallow levels in the conduit. In contrast, the minor drop in fragmentation level implied from the upward decrease in vesicularity in the CGT may have been caused by water access to the conduit near the fragmentation level as indicated by the relatively abundant lithic fragments.

References

Kutterolf S, Freundt A, Pérez W, Mörz T, Schacht U, Wehrmann H, Schmincke H-U (2008a) The Pacific offshore record of Plinian arc volcanism in Central

America, part 1: Along-arc correlations. Geochem Geophys Geosyst 9 doi:10.1029/2007GC001631

Kutterolf S, Freundt A, Pérez W (2008) The Pacific offshore record of Plinian arc volcanism in Central America, part 2: Tephra volumes and erupted masses. Geochem Geophys Geosys 9, doi:10.1029/2007GC001791

Walker GPL (1971) Grain-size characteristics of pyroclastic deposits. J Geol 79: 696-714

Sedimentological analysis of tsunami deposits along the coast of Peru

Piepenbreier J 1, Spiske M 1, Benavente C 2, Steffahn J 3 Bahlburg H 1

1 Westfälische Wilhelms-Universität, Geol.-Paläontol. Inst., Corrensstr. 24, 48149 Münster, Germany, j.piepen@gmx.de

2 Instituto Geológico, Minero y Metalúrgico INGEMMET, Av. Canadá 1470, Lima, Peru

3 Facultad de Ciencias de la Tierra, Universidad Autónoma de Nuevo Léon, Mexico

The Peru-Chile-Trench is one of the most active seismic areas in the world (Kulikov et al., 2005). The subduction of the Nasca Plate under the South American Plate causes earthquakes with magnitudes greater than 8 every 5 to 10 years. Consequently, the risk for destructive tsunami along the coast of Peru is very high. The greatest historical tsunami events in this region are the two Arica tsunami in 1604 and 1868 (Okal et al., 2006) and the Chile tsunami in 1960 (Cisternas et al., 2005). The most recent tsunami are the Chimbote tsunami in 1996 (Bourgeois et al., 1999) and the Camaná tsunami in 2001 (Jaffe et al., 2003). Additionally, in 2007, a magnitude 7.9 earthquake 150 kilometres SSE of Lima generated a tsunami with run up heights of 10 m along the southern Paracas Peninsula (Fritz et al., 2008).

Despite a large increase in tsunami studies in the last years, there is still no complete tsunami facies model. Furthermore the hydrodynamical processes leading to deposition of sediment by a tsunami wave are still not well understood. We surveyed various locations along the 2400 km Peruvian coastline to locate deposits of recent and historical tsunami events. Deposits were studied in trenches and boreholes down to depths of 3 m. We separated the foraminifera content for identification and inference of water depths of sediment entrainment by the tsunami. The grain-size distributions of the sampled deposits were optically determined with a PartAn 2001 particle analyser. The grain-size data were used to re-model the flow depths, using the inverse tsunami model of Jaffe & Gelfenbaum (2007).

Recent tsunami deposits of the 2007 event were surveyed in the regions of the Paracas Peninsula and Pisco. At the southern side of the Paracas Peninsula, beige beach sand is overlain by a 25 cm thick more bright coloured layer of shell and

gravel, whereas the gravel is sandwiched between layers of sand and shell. This bright material represents the tsunami deposit. The imbricated gravels and shells indicate bedload transport.

30 km north of Pisco the beach sand is overlain by a succession of tsunami layers. The grain size distribution of the beach sand is bimodal with modes at 0.36 mm and 0.56 m. A 3 cm thick layer of coarse sand represents the base of the tsunami deposit. The material shows an irregular grain-size distribution with modes in the field of coarse sand (0.60 mm) and shell material of fine gravel (7.20 mm) size. On the top of the tsunami succession, muddy rip up clasts with a maximum diameter of 29 cm lie in a matrix of sand, which also contains shells. The grain size distribution of the matrix is similar to the one of the subjacent material, but shows an additional mode at a grain size of 4 mm. The main difference between the beach sand and the tsunami sand is the wide size range (0.25 –8 mm) of the tsunami deposits in contrast to a narrower size distribution (0.3-0.7 mm) of the beach sand. The material of the rip up clasts was derived from an agricultural field in a distance of 150 m and was transported seawards by the backwash of the tsunami wave. A 5 cm thick layer of sand represents material deposited after the tsunami.

Paleotsunami deposits were found, for example, in Puerto Casma (northern Peru) and Boca del Rio (southern Peru). At Puerto Casma a 3 cm thick layer of coarse grained material was found in finer grained beach sediment in a depth of 60 cm. The layer has an erosional contact at the base with heavy minerals and contains shell fragments and very fine gravel up to a size of 1.5 cm. Three trenches were dug to track the deposits and to prove a landward fining trend of the grain size within this layer: the mean grain size changes from 0.507 mm in a distance of 10 m from the coastline to 0.424 mm (15 m distance) and finally to 0.415 mm (30 m distance). Furthermore, sorting improves landward, although all three samples are very poorly sorted: the sorting is 2.362 in 10 m distance from the shore, 2.071 in 15 m distance, and 2.025 in 30 m distance. At the site of Boca del Rio two sandy layers with a thickness of 4 cm occur in argillaceous soil. The graded sand layers with shell fragments and fine gravel appear in depths of 30 cm and 40 cm below the surface and seem to represent two palaeotsunami events.

Benthic foraminifera in recent and historical tsunami deposits were only present at two locations. Whereas, at these two locations foraminifera do not only occur in the event deposits, but in the beach sand as well. Planktonic foraminifera were completely absent. The overall condition of the encountered foraminifera can be characterized as very bad. In many cases an identification of the species was not possible. The foraminiferal tests often show abrasion and secondary crystallisation and are broken or dissolved. We assume that the reason for the bad preservation of the tests is not grain to grain abrasion during transportation of sediments but reworking of older sediments. The foraminifera represent post-mortem transport and the reliability is limited. Therefore a statement about the bathymetry is not possible.

References

Bourgeois J, Petroff C, Yeh H, Titov V, Synolakis C E, Benson B, Kuroiwa J, Lander J, Norabuena E (1999) Geologic Setting, Field Survey and Modeling of the Chimbote, Northern Peru, Tsunami of 21 February 1996. Pure and Applied Geophysics 154: 513-540.

Cisternas M, Atwater B F, Torrejón F, Sawai Y, Machuca G, Lagos M, Eipert A, Youlton C, Salgado I, Kamataki T, Shishikura M, Rajendran C P, Malik J K, Rizal Y, Husni M (2005) Predecessors of the giant 1960 Chile earthquake. Nature 437: 404-407.

Fritz H M, Kalligeris N, Borreo J C, Broncano P, Ortega E (2008) The 15 August 2007 Peru tsunami runup observations and modeling. Geophysical Research Letter 35 L10604.

Jaffe B E, Gelfenbaum G (2007) A simple model for calculating tsunami flow speed from tsunami deposits. Sedimentary Geology 200: 347-361.

Jaffe B, Gelfenbaum G, Rubin D, Peters R, Anima R, Swensson M, Olcese D, Anticona L B, Gomez J C, Riega PC (2003) Identification and interpretation of tsunami deposits from the June 23, 2001 Peru tsunami. Proceedings of the International Conference on Coastal Sediments 2003 CD-ROM published by World Scientific Corp and East Meets West Production Corpus Christi Texas USA.

Kulikov E A, Rabinovich A B, Thomson R E (2005) Estimation of tsunami risk for the coasts of Peru and Northern Chile. Natural Hazards 35: 185-209.

Okal E A, Borrero J C, Synolakis C E (2006) Evaluation of Tsunami Risk from Regional Earthquakes at Pisco, Peru. Bulletin of the Seismological Society of America Vol 96 No 5: 1634-1648.

Mantle reference frame and generation of detached- and flat-slab subduction geometries in Caribbean evolution

Pindell J

Dept. Earth Science, Rice University, Houston, Texas USA, jim@tectonicanalysis.com

Slab dip during subduction is often correlated with the relative buoyancy of the subducting slab with respect to normal oceanic crust. This paper uses the Caribbean region to explore how the motion of the overriding plate relative to the local mantle can control slab dip, as well. Opposing polarities of the Lesser Antilles/Aves Ridge and Middle American arcs prevented the Caribbean Plate from having significant E-W motion in the Indo-Atlantic mantle reference frame while both arcs were active (since Santonian, 85 Ma). During this time, the Americas drifted west relative to the mantle and their Proto-Caribbean margins collided with segments of the stationary Great Caribbean arc at southern Yucatan (70Ma), Ba-

hamas (40Ma), and eastern Venezuela (12Ma). These margins had subductable oceanic slabs that faced partly westward in the direction of plate advance. Prior to collision at each, convergence occurred by American slabs entering sub-Caribbean mantle, like at today's Lesser Antilles. Upon collision, however, buoyant American continental crust choked subduction such that westward drift could only continue by detaching from and overthrusting the former oceanic slabs; the detached south Yucatan and Bahamian slabs should now underlie the eastern Colombian Basin and Silver Plain region, respectively. The Eastern Venezuelan slab may still be detaching by eastward tearing. In contrast, when W-drifting American continental crust forms hanging walls to E-dipping subduction (Andean type), flat-slab geometries result because the continental forearcs are progressively thrust across established trench positions. Along Neogene SW Mexico, flat slab Cocos lithosphere enters the mantle due to its own velocity relative thereto, and creates an arc far from the trench. However, along NW Colombia, the Caribbean Plate, being fixed in the mantle, has NOT entered the mantle while being overridden by Colombia, possibly contributing to lack of an arc. At Andean settings like these, orogenic intensity depends on the rate of trenchward hanging wall advance relative to roll back, and the buoyancy (crustal age, thickness and petrology), of the downgoing plate. By comparing local Caribbean geo-histories at these two types of collisions, it appears that Andean-type examples can cause much greater uplift due to resultant doubling of the crust.

Mejoras del proceso de beneficio de minerales auroargentíferos del Distrito minero Vetas-California (Santander-Colombia) para reducir la contaminación ambiental.

Pinzón Ángel JM

Proyecto Río Suratá – Convenio CDMB - BGR, juan.pinzon@cdmb.gov.co

La minería de oro artesanal en Colombia se ha caracterizado por la utilización de sustancias químicas fuertemente contaminantes y de alto impacto ambiental negativo como el mercurio y el cianuro, además de obtener bajos rendimientos económicos del procesamiento de minerales auríferos. En Santander se presenta el agravante de la resistencia al cambio del minero a introducir o modificar sus prácticas, debido probablemente al medio generacional de transmisión de conocimientos, que crea una barrera que los mineros expresan como "siempre lo hemos realizado así", limitando así sus posibilidades de mejoramiento tecnológico y ambiental.

Los municipios de Vetas y California son áreas de explotación aurífera a partir de filones o vetas, que utilizan mercurio para la recuperación del oro libre y cianuro para la disolución del oro fino en combinación con precipitación con zinc en viruta. Estos municipios han tenido actividad minera desde hace 400 años, condición

que también hace más difícil la introducción de técnicas menos contaminantes y mas competitivas. El bajo costo del mercurio, su fácil adquisición, rapidez de reacción y facilidad de manejo, lo convierten en la técnica preferida para el oro grueso (oro mayor a 100 micrones). Los anteriores aspectos sumados a factores como falta de ajuste mecánico y químico, hacen de la amalgamación la técnica más contaminante para la recuperación de oro.

En 1990 algunas empresas iniciaron la conversión tecnológica, introduciendo sistemas de concentración gravimétrica, disminuyendo la presión sobre la amalgamación e introduciendo la recuperación de oro limpio en bateas. Gradualmente aumentó el interés por el tema ambiental generando nuevos espacios, los cuales les han conducido al mejoramiento de las técnicas, con la incorporación de nuevas tecnologías y con el cambio de prácticas de proceso lográndose reducir la contaminación. En cuanto al cianuro, existía desconocimiento total del fundamento químico que controla la disolución del oro, caracterizándose la técnica por bajos requerimientos en seguridad industrial y salud ocupacional en la manipulación del reactivo, no se aplicaban los criterios mínimos de control de pH y concentración de cianuro para la operación del proceso y por el contrario, la disolución del oro fino se realizaba en forma técnicamente no apropiada, antieconómica y generando gran contaminación, debido a que las etapas subsecuentes involucran la recuperación del zinc cargado con oro, su fundición y purificación, etapa última que utiliza acido nítrico, confirmándose que la elevada concentración de cianuro, se convertía en el elemento desencadenante de la contaminación ambiental.

Los anteriores aspectos, sumados a la limitante topográfica para la disposición de las colas de cianuración y amalgamación, definieron la connotación altamente contaminante de la actividad minera en los municipios de Vetas y California, que llegó a impactar negativamente la calidad del agua del río Suratá, fuente de abastecimiento de agua cruda para la compañía Acueducto Metropolitano de Bucaramanga, empresa prestadora de servicios públicos que suministra el agua potable para Bucaramanga y su área metropolitana con cerca de un millón de habitantes.

Bajo el contexto anterior, fue muy importante identificar estrategias de inserción de tecnologías limpias en el campo del beneficio de minerales y más importante que las mismas tecnologías, identificar la vía o manera para llegar directamente al minero e introducir cambios de procedimientos y de equipos que perduraran en el tiempo. De esta manera se definió la importancia de realizar pruebas a nivel de laboratorio y pruebas piloto directamente en las minas, que pudieran en forma real y concreta demostrar al minero las bondades productivas y ambientales derivadas de la adopción de las nuevas técnicas.

Con bajo nivel de inversión económica, se implementaron sistemas sencillos de concentración gravimétrica como los canalones, los cuales fueron adoptados en aproximadamente 10 empresas de las 23 unidades del distrito, teniendo como fundamentación el obtener menor cantidad de preconcentrado pero de mejor calidad, lográndose reducir la cantidad de mineral que se procesaba por amalgamación y por lo tanto, reducir el consumo de mercurio. Posteriormente se introdujeron si-

stemas mecanizados de concentración de fabricación nacional como mesas concentradora tipo Wifley, Jig concentrador tipo Denver, y espirales concentradores.

El anterior concepto estaba fundamentado en trabajar directamente en la fuente para reducir la contaminación por mercurio; sin embargo también fue necesario intervenir el proceso de amalgamación, ajustando los parámetros que definen la eficiencia del proceso como velocidad de los barriles de amalgamación, relación de sólido a liquido en la pulpa, la calidad del agua y del mercurio utilizados, la utilización de activadores electrolíticos de mercurio, la adición de sustancias para reducir la viscosidad de la pulpa y el sistema final de recuperación de mercurio y amalgama (mezcla física de oro y mercurio), con el objeto fundamental de reducir las pérdidas de mercurio en el proceso, las cuales se redujeron de 50 % a 10%.

La separación mercurio-oro por vía térmica al aire libre estaba generando gran contaminación por la emisión de vapores a la atmosfera. En estrecha interacción con los mineros, se identificaron las falencias y expectativas del sistema de destilación (mejor conocido como "Retortas") que definieron pautas en el nuevo diseño y mediante pruebas de laboratorio y pruebas en campo, fue posible construir un sistema integrado por horno-retorta-quemador que recupera mas del 90% del mercurio, utiliza combustibles limpios y en 10 minutos de operación registra temperaturas de 600 °C. El sistema es operado con éxito en Santander y también ha sido introducido a departamentos como Guainia y Choco, con resultados muy positivos en los cuales se registra reducción en la emisión de mercurio superior al 70%.

En la cianuración se ajustaron inicialmente los parámetros de control (eliminación de sales solubles, ajuste de pH y concentración de cianuro utilizada, duración del tiempo de reacción) los cuales permitieron disminuir la contaminación en 20% y en forma simultánea se realizaba la capacitación "*On the job*" de los mineros para su autogestión y autocontrol del proceso. Integrando la concentración gravimétrica, fue posible hacer más selectiva la cantidad de mineral a someter a cianuración (aplicando solamente cianuro a los concentrados gravimétricos), cambiando la cianuración por percolación a cianuración por agitación, representando un avance tecnológico de 100 años, representando esta última en un aumento de la productividad y consolidándose como la herramienta para la destrucción del cianuro residual utilizando peróxido de hidrogeno.

Para cerrar el ciclo tecnológico y hacer mas competitiva y sostenible la actividad minera, se incorpora la precipitación del oro presente en las soluciones de cianuro utilizando zinc en polvo, con la expectativa reducir las concentraciones de cianuro entre un 30 y un 40 %, reduciendo los costos de operación y principalmente la contaminación ambiental. La sostenibilidad de la agitación se manifiesta en la forma como se han multiplicado las empresas que con recursos propios implementan la técnica y se proyecta como al opción más viable para la eliminación del mercurio en el proceso, forma como lo han asumido algunas empresas, acompañada de equipos de la gama de la concentración centrifuga, destinados a la recuperación de oro fino sin la utilización del cianuro.

References

Pinto E, Wolff E, Pincon JM, Pineda JC (2007) Resultados y experiencias exitosas de proyectos relacionados con el Manejo de Mercurio en la Minería de Oro en Colombia con fines preventivos. ISBN 978-958-97978-9-1.

Wolff E, Pincon JM, Contreras R, Bernardy Cernardy C (2005) Geological setting, mining and reduction of mercury vapor contamination in the gold-silver district of Vetas-California (Santander, Colombia). Revista Episodes Journal of Internacional Geoscience IUGS Vol. 28 4: 252-256.

Devonian and Ordovician Magmatism in the Maya Block: Chiapas Massif area, SE Mexico

Pompa-Mera V 1, Schaaf P 1, Weber B 3, Solís-Pichardo G 2, Hernández-Treviño T 1, Ortega-Gutiérrez F 2

1 Laboratorio Universitario de Geoquímica Isotópica, Instituto de Geofisica, UNAM, México, valerie@geofisica.unam.mx
2 Instituto de Geología, UNAM
3 Centro de Investigación y Estudios Superiores de Ensenada, México

Southern Mexico is considered as a “collage” of Tectonostratographic Terrains with different geological histories and evolutions. Correlations between these terrains in regard to North and South America have been discussed extensively in the last years. In the eastern part of the Maya Block, the oldest sequences are represented by metasedimentary rocks widely distributed in Guatemala and Belize (Santa Rosa Formation). To the south, the Chiapas Massif Complex (CMC) constitutes the largest batholitic complex in Mexico, mainly formed by igneous, metaigneous and metasedimentary rocks. Several magmatic and metamorphic events between Late Permian and Triassic times have been identified in these rocks as well as a Jurassic tectonothermal overprint. In this work, we analyzed samples from the southeastern part of the CMC close to Motozintla de Mendoza. Geochemical and isotopic data show that these rocks have been formed in Within Plate as well as Magmatic Arc enviroments. Anatexis and igneous magmatic differentiation in upper and medium levels of the continental crust formed “I” and “S” type granites. Nd model ages, $^{87}Sr/^{86}Sr$ and epsilonNd parameters, suggest that the magmatic precursors of these rocks have been involved in continuous crustal recycling processes. Our new geochronological results include a Rb-Sr biotite-muscovite age of 392+9 Ma, and an Ar-Ar muscovite age of 406+4 Ma from a granitic body emplaced within a metasedimetary sequence. From an amphibolitic unit we obtained an age of 456+14 Ma (U-Pb, single grain zircon) and additionally we determined two ages of 476+14 Ma (Sm-Nd in garnet), and 482+3 Ma (U-Pb, single grain zircon) from an “S” type granitic body. The geochronological information of magmatic and metamorphic rocks from this part of CMC clearly demon-

strates that the basement of this complex was affected by magmatic and metamorphic events since Ordivician and Devonian times. On other hand, we identified a new CMC basement (Jocote Unit) significantly older than the Carboniferous Santa Rosa Formation, which has been considered up to now as its predominant basal sequence. These ages represent a key tool for understanding the old assemblage between the crustal blocks at the Maya-Chortís boundary during Paleozoic times focusing the paleo-tectonic scenario, temporal rock relationships, metamorphic conditions and magma emplacement mechanisms.

References

Schaaf, P., Weber, B., Gro , A., Ortega-Gutiérrez, F., and Köhler, H., 2002: The Chiapas Massif (México): New Geologic and Isotopic data and basement characteristics, N. Jb. Geol. Paläont Abh. 225: 1-23.

Weber, B., Iriondo, A., Premo, W.R., Hecht, L., and Schaaf, P., 2007: New insights into the history and origin of the Southern Maya Block SE Mexico U-Pb SHRIMP zircon geochronology from metamorphic rocks of the Chiapas Massif, International Journal of Earth Sciences 96: 253-269.

The copper and bitumen mineralization in Barda Gonzáles and Tordillos prospects, Nequén, Argentina

Pons MJ 1, Franchini MB 1, Giusiano A 2, Licitra DT 3

1 Grupo Patagónico de Estudios Metalogenéticos-CONICET-CIMAR, Universidad Nacional del Comahue, jpons@uncoma.edu.ar

2 Dirección Provincial de Hidrocarburos y Energía de la Provincia del Neuquén

3 YPF, Neuquén.

Barda González and Tordillos are two examples of the main stratiform sedimentary copper in Neuquén Province, Argentina. They are located in the Huincul Ridge (Dorsal de Huincul area), near hydrocarbon fields (Fig. 1). Based upon previous works of these cupriferous manifestations (Wichmann, 1927; Fernández Aguilar, 1945; Granero Hernández and Schmid, 1956; Ramos, 1975; Lyon, 1999) and the preliminary results obtained in some Giusiano et al., 2006; Giusiano et al., 2008 proposed a new hypothesis that associates the cupriferous manifestation with the hydrocarbons and Cu-fluids migration along the main structures related to the Huincul Ridge. The origin of this hydrocarbons and fluids is located in the deepest levels of this structure. The Huincul Ridge is a structural lineament of regional scale developed at 39º South latitude, with a E-O strike extended along 270 km (Fig. 1), that defines the natural northern boundary of Argentina Patagonia with the Neuquén Basin (Ramos et al., 2004). This structure was interpreted as a fault

zone of dextral lateral movement with the coexistence of transpressive and transtensive segments as resulted of changes in the fault zone trend. Silvestro and Zubiri (2008) proposed that this ridge is the result of an oblique NW-SE convergence between the Northpatagonian Craton at the Southeast and the Neuquén basin at the Northwest. These researchers identified inside this deformation belt three segments. The western sector with the predominance of NE trending anticlines, a central zone with E- W lineaments of compressive and wrench structures and a northern and eastern zone where the lineaments are NW trending and developed right-lateral wrench structures. The faults from the central, northern and eastern zones were developed from the previous normal faults of the Triassic rift by the tectonic inversion during the Upper Jurassic and Cretaceous (Cruz et al., 2002; Silvestro and Zubiri, 2008). Most of these faults have an origin in deep levels and abort in the base of the Vaca Muerta Formation (Tithonian) and others closer to the main fault have their origin in shallower levels and cut the Neuquén Group (Upper Cretaceous) (Schiuma et al., 2002).

The copper deposits are hosted in the fluvial deposits of the Neuquén Group (Cenomamian- Campanian). These rocks cover almost all the center east of the Neuquén basin with up to 1300 m thick in the embayment zone (Cazau and Uliana, 1972). These rocks lay unconformilly over the continental sedimentary rocks of the Rayoso Group (Aptian-Albian) and are cover by the marine deposits of Malargüe Group (Lower Maastrichian-Upper Campanian). Neuquén Group is composed by Río Limay Subgroup with Candeleros, Huincul and Lisandro Formations, Río Neuquén Subgroup with Portezuelo and Plottier Fromations and Río Colorado Subgroup with Bajo de la Carpa and Anacleto Formations (Ramos, 1981; Fig. 2). They consist in fine to coarse sandstone and conglomerate interbedded with claystones and mudstones, and is cemented by iron oxides and hydroxides that give them a typical red color.

The Barda González prospect is hosted in Portezuelo Formation (Neuquén Group), located in the central fault zone of the Huincul Ridge (Fig. 1c) next to Barda González, Bajo Barda González, and Puesto Espinoza oil fields. The Cu mineralization has an extension of 600 m wide by 2000 m long with a NNE stricke (Fig. 3), along fluvial paleochannels, defined by coarse sandstone and conglomerate layers. These rocks only reach the early diagenesis stage and are discolored and altered. They are very permeable due to the lack of iron oxides and hydroxides and the total or partial disolution of their cement and their feldespar and volcanic lithic. These last are also altered to clay minerals (illite>kaolinite). The copper minerals are diseminated, concentrated in beding, tubes or nodules always in contact with bitumen (Fig. 3c). They consits of chalcocite, covelline, trace of chalcopyrite, and a variety of supergene minerals (malachite, with chrysocolla, brochantite, azurite, tenorite, turquoise, atacamite, voborthite). There are also diseminate pyrite and psilomelane trace. The geochemistry of bitumen indicates that it is a hydrocarbon migration residue generated from a marine rock between the Lower Triassic and Upper Cretaceus (Los Molles or Vaca Muerta Formations).

The Tordillos prospect is hosted in the Huincul Formation, located in the northern flank of the Huincul Ridge, west of the Loma la Lata hydrocarbon (gas) field and at the left margin of the Neuquén River (Fig. 1c). It is situated in the Alto del Sauzal Bonito anticline, a structure product of the tectonic inversion of the Jurassic fault wich has an E-W strike sloping to the NNE (Maretto y Pángaro, 2005). In the prospect area there are a series of fractures with E-W, NNW and N-S orientations that could be the shallow expressions of the normal fault observed in the subsurface which was reactivated during the Andean orogeny (Maretto et al., 2005). The copper and bitumen mineralization extend in a series of tableland along 6 km alienated with an orientation E-W that conform the outcrops of the Huincul Formation (Fig. 4a, b). This Formation is composed by feldspar-quartz rich sandstone and conglomerates with features of filling channel deposit fining upward. Theses rocks have a grayish color due the leaching of the iron oxides and hydroxides, the alteration of their volcanic lithics and feldspars to clay minerals, and the bitumen impregnations. The copper mineralization is disseminated as tables (filling join), tubes (Fig. 4c), bubbles and cylinder cutting the sedimentary structures and also as fines layers along the stratigraphic bedding planes, always associated with bitumen. The mineralization consists in calcocite partial to totally replaced by crysocolla with trace of malachite filling the porosity. The bitumen is also riming and filling the cavities the previous fibers of the fossil trunk fragments which are partially replaced by crysocolla, malachite and azurite (Fig. 4d).

Both present the following similarities: 1) they are located in the Huincul Ridge region, Neuquen basin, 2) mineralization is restricted to the permeable paleochannels of the Neuquén Group and consist in copper sulfur (calcosite, covelite, traces of chalcopyrite) and supergene minerals (crysocolla, brochantite, malachite, atacamite) that are intimately associated with bitumen, 3) they are situated near the structures related to the Huincul Ridge and the hydrocarbon fields Bajo Barda González (oil) and Loma la Lata (gas), 4) in both fields the formation waters of the reservoir are chlorides rich brines (60 to 72 gr/l chlorides, Schiuma et al., 2002; Maretto et al., 2005). These water that migrate along with hydrocarbons through the faults and permeable beds, could have extract the copper from the iron oxides and hydroxides of the continental red beds. The passage of these fluids, in contact with the permeable levels of the Portezuelo and Huincul Formations, could have generated the consequent alteration and permeability increase in the host rocks and the precipitation of the copper sulfur in the water/hydrocarbons interface.

Figure 1. a-b) Location map of the Neuquén basin and the Huincul Ridge, with the c) distribution of the hydrocarbons fields and copper deposits, and the location of Barda González and Tordillos.

Figure 2. Stratigraphic column of the Neuquén Group from the Huincul Ridge, showing the host rocks of the Barda González and Tordillos prospects with different degree of alteration (Modify from Giusiano et al., 2008).

Figure 3. a) Geologic map of Barda González and b) the cross section NE-SW showing the distribution of copper mineralization, c) samples of the mineralized rocks their location is shown in the figure 3a.

Figure 4. a) Geologic map of Tordillos and b) the cross section N-S showing the distribution of the copper mineralization, c) field picture of the Huincul Formation out crop with the copper tubes cutting the bedding planes, and d) examples of the fossil trunk with copper mineralization hosted in the Huincul Formation.

References

Cazau L, Uliana M, 1972. El Cretácico Superior continental de la Cuenca Neuquina. In Congreso de Geología Argentina, N° 5, Actas 3, 131-163. Villa Carlos Paz, Córdoba

Cruz C, Boll A, Gómez Omil R, Martínez E, Arregui C, Gulisano C, Laffitte G, Villar H, 2002. Hábitat de hidrocarburos y sistemas de carga Los Molles y Vaca Muerta en el sector central de la Cuena Neuquina, Argentina. In Congreso de Exploración y Desarrollo de Hidrocarburos, N° 5, CD Trabajo N° 29, 20. Mar del Plata.

Fernández Aguilar R 1945. Los yacimientos de areniscas cupríferas del Neuquén. Dirección de Minas, Geología e Hidrología, Publicación 58, 1-27. Buenos Aires.

Giusiano A, Franchini M, Impiccini A, O`Leary S, 2006. Mineralización de Cu asociada a bitumen en las areniscas cretácicas, prospecto Barda González, Neuquén, Argentina. In Congreso Geológico Chileno, N° 11, Actas 2, 255-258. Antofagasta.

Giusiano A, Franchini MB, Impiccini A, Pons M J, 2008. Mineralización de Cu en sedimentitas Mesozóicas del Grupo Neuquén y hábitat de los hidrocarburos en la Dorsal de Huincul Neuquén. En el Congreso Geológico Argentino 2008, Resumen in extenso para el Simposio de Cuenca Neuquina, p. 769-770.

Granero Hernández A, Schmid J, 1956. Estudio geológico económico de las areniscas cupríferas de la zona de Plaza Huincul. Dirección General de Fabricaciones Militares, Informe N° 191, 93 p. Biblioteca SEGEMAR. Buenos Aires.

Lyon W, 1999. Las areniscas cupríferas del Neuquén. In Recursos Minerales de la República Argentina (Zappettini, E.; editor). Instituto de Geología y Recursos Minerales, SEGEMAR, Anales 35, p.1149-1158. Buenos Aires.

Maretto H, Pángaro F, 2005. Edad de formación de algunas de las grandes estructuras del engolfamiento de la Cuenca Neuquina: Actividad tectónica durante la depositación de la Formación. Quintuco. Congreso de Exploración y Desarrollo de Hidrocarburos, N° 6, CD. Mar del Plata.

Maretto H, Martínez Lampe J, Rodriguez L, Berdini O, Schachner G, Castellarini P, Arregui C, Quinteros J, Martínez E, Lasalle D, Pecuch D, 2005. Condiciones de entrampamiento en el sector sur del Engolfamiento Neuquino. Introducción. In Las trampas de hidrocarburos en la Cuencas Productivas de Argentina (Kozlowski, E.; Vergani, G.; Boll, A.; editores). Congreso de Exploración y Desarrollo de Hidrocarburos, N° 6, p. 261-270. Mar del Plata.

Ploszkiewicz J, Orchuela J, Vaillard R, Viñes R, 1984. Compresión y desplazamiento lateral en la zona de Falla Huincul, estructura asociadas, Provin-

cia del Neuquén. In Congreso Geológico Argentino, N° 9, Actas 2, 163-169. San Carlos de Bariloche.

Ramos VA, 1975. Los ciclos sedimentarios y biorhexistacia en el control de las manifestaciones cupríferas del Neuquén extraandino, Argentina. In Congreso Ibero-Americano de Geología Económica, N° 2, Actas 5, 373-394. Buenos Aires.

Ramos VA, 1981. Descripción geológica de la Hoja 33c. Los Chuihuidos Norte. Servicio Geológico Nacional Boletin 182: 1-103, Buenos Aires.

Ramos VA, Ricardo A, Rolleri E, 2004. Límites naturales del norte de la Patagonia. Revista de la Asociación Geológica Argentina 59 (4): 785-786.

Schiuma M, Saavedra C, Malone P, Cevallos M, Rebori L, Vergani G, 2002. Los reservorios del Gupo Lotena. Argentina. In Rocas Reservorios de las Cuencas Productivas de la Argentina (Schiuma, M.; Hinterwimmer, G.; Vergani, G; editores).Congreso de Exploración y Desarrollo de Hidrocarburos, N° 5, p. 303-334. Mar del Plata.

Silvestre J, Zubiri M, 2008. Convergencia oblicua: Modelo estructural alternativo para la Dorsal neuquina (39° S)- Neuquén. Revista de la Asociación Geológica Argentina 63(1): 49-64.

Wichmann L, 1927. Los estratos con dinosaurios y su techo en el este del territorio de Neuquén, Dirección General de Minería, Geología e Hidrología, Publicación N° 32. Buenos Aires.

Hydrogeology and Hydrochemistry of groundwater in the Pablillo River Basin Linares, Nuevo Leon, Mexico.

Dávila Pórcel RA1, De León Gómez H 1, Velasco Tapia F 1, Hoppe A 2, Schüth C2

1 Facultad de Ciencias de la Tierra, Universidad Autónoma de Nuevo León. México. rene.alberto.davila@gmail.com

2 Institut für Angewandte Geowissenschaften, Technische Universität Darmstadt

A sustainable use of groundwater resources requires knowledge related to recharge regime, aquifer characteristics, physicochemical quality, exploitation and management of groundwater, and potential pollution sources (Custodio, 2004). The main objective of this study has been to investigate the characteristics and availability of the groundwater resources in the eastern section of the Pablillo River Basin, NE Mexico (area ~ 1734 km2). Linares and Hualahuises urban centers are located inside this region, reaching a total population of 77000 inhabitants on 2005 (INEGI, 2005). Initial step of this research program has included the description of physiographic and geological features, the hydrogeological framework, and a hydrochemical evaluation. All these data have been included in a Geographic Information System (GIS). Study area lies around the Linares Nuevo León, Mexico. It covers a surface of about 192 km2 of the Pablillo River Basin. The most impor-

tant drainage feature of the study area is the Pablillo River and its tributaries (Hualahuises and Camacho Rivers). Cerro Prieto dam is a source of potable water and a remarkable land feature on the Pablillo River in the eastern part of the basin. It is an important water supply for Monterrey, the main urban center in the NE Mexico with more than 3.5 million inhabitants (INEGI, 2005). From the physiographic point of view, the Linares and Hualahuises region is situated on the Gulf of Mexico Coastal Plain (GMCP; De Cserna, 1989). It is included inside the Northern subtropics latitudinal zone (Strangeways, 2007). The region shows a subtropical semiarid climate, with hot summers (canícula 48°C) and severe frosts in some winters (-12°C). Average annual temperature and rainfall are 23.5°C and 800 mm respectively, where ~80% of precipitation usually falls during May- October. Study area is flanked in its western sector by the Sierra Madre Oriental, a Jurassic- Cretaceous fold-thrust sedimentary belt (Goldhammer, 1999). The main geological units that outcrops in the study area include: (a) San Felipe Formation (Turonian-Coniacian; maximum thickness ~150 m), consisting of a sequence of thin-bedded, laminated gray limestones, interbedded with shales, porcellanites, greensands; (b) Mendez Formation (Campanian-Maastrichtian; maximum thickness >1500 m), constituted by dark gray to black fissile shale, with some minor intercalations of dark-olive, calcareous shale; and (c) Long lines of Tertiary-Quaternary fluvial terraces and lacustrine sediments (maximum thickness ~25 m), covering a great part of GMCP, that originated at the mouths of the SMO canyons. Geological and hydrogeological information was collected from 24 water wells distributed in the study area. A global positioning system (GPS), Garmin HCx, was used for location and elevation readings. This was supported by topographic digital sheets made available from the INEGI. In-situ measurements included piezometric head (m), pH, electrical conductivity (EC, μS/cm), temperature (T, °C), and identification and recognition of the water- bearing layers. Twenty-four groundwater samples were collected in polyethylene bottles. Samples were further analyzed for total hardness, Na+, K+, Ca+2, Mg+2, alkalinity, Cl-, SO4-2, NO3-, metals, and total dissolved solids (TDS). Standard methods were used for the determination of the chemical characteristics of the water samples. From field work and field surveys were conducted to study the geology, groundwater occurs in the Pablillo River Basin in two main water-bearing hydrologically connected layers: (a) a lower fractured and weathered shale on the bottom of aquifer composed by Mendez and (b) an upper permeable and porous alluvium deposits that consist mainly of gravels and various grades of sand, silt and clay. Groundwater is stored and transmitted through the fractured and weathered bedrock and the overlying alluvial deposits (Al-Shaibani, 2008). In general, groundwater occurs under water-table condition in the shallow aquifer, and semi-confined to confined condition in the deeper aquifer. Average depth of water-table in the study area is ~9.3 m. Structural geological data and regional flow shows that the same direction of groundwater flow is SW-NE. Geochemical analysis has revealed that the TDS ranged from 294-1455 mg/l. A highest value of 3428 mg/l was ob-

served in the Ejido La Escondida well, located in the NE sector of the study area. Piper diagram illustrates a data distribution from calcic-bicarbonate (samples located in the border basin; EC~400-600 µS/cm) to calcic-sodic-chloride domains (samples situated in the discharge zone; EC~4200 µS/cm). This change in hydrochemical facies are a function of lithology, solution kinetics, and flow patterns in the aquifers.

References

Al-Shaibani A. M., (2008) Hydrogeology and hydrochemistry of a shallow alluvial aquifer, western Saudi Arabia. Hydrogeology Journal (2008) 16: 155–165.

Custodio E., (2004) Hidrología Urbana: una nueva rama de la ciencia hidrogeológica. Bolitin Geologico y Minero, 115, Numero especial: 283-288.

De Cserna Z., (1989) An outline of the geology of Mexico. In: Bally, A.W., Palmer, A.R. (eds.), Decade of North American Geology, Volume A: The Geology of North America – An overview. Geological Society of America, Boulder, CO, p. 233-264.

De León-Gomez H., Schetelig K., Meiburg P., (1994) Abastecimiento de Agua Potable en el Noreste de México. Ejemplo: Presa Cerro Prieto. Zentralblatt für Geologie und Paläontologie. Teil 1, H.1/2:593-602, 6 Abb., ISSN 0340- 5109, Stuttgart, Alemania.

Goldhammer R.K., (1999) Mesozoic sequence stratigraphy and paleogeographic evolution, Northeast Mexico. In: Bartolini, C., Wilson, J.L., Lawton, T.F. (eds.). Mesozoic sedimentary and tectonic history of North-Central Mexico. Geological Society of America Special Paper 340, 1-58.

Instituto Nacional de Estadística y Geografía, (INEGI; 2005), Segundo Conteo de Población y Vivienda 2005.

Montalvo-Arrieta J.C., Quintanilla Y., Tamez A., Meneses M., Ramos L., Masuch D., (2005) Microzonation of the Linares, Northeast Mexico area, based on geology and shear-wave velocity measurements. Geofísica Internacional (2005), Vol. 44, Num. 4, pp. 331-340.

Sánchez – Vila X., (2004) Hidrogeología urbana: algunos efectos específicos. En Portada – Nº 41 (2004) Ecotropia. Actualidad y recursos de las ciencias ambientales.

Strangeways I., (2007) Precipitation: theory, measurement, and distribution. Cambridge University Press, Cambridge, UK, 290 p.

Tahir Hussein M., (2003) Hydrochemical evaluation of groundwater in the Blue Nile Basin, eastern Sudan, using conventional and multivariate techniques. Hydrogeology Journal (2004) 12:144–158

Slow earthquakes on the Nicoya, Costa Rica, seismic gap

Protti M 1, V. González V 1, PsencikK 2, DixonT 2, Schwartz S 3, LaFemina P 4, Kato T 5, Melborne T 6

1 OVSICORI, Universidad Nacional, Costa Rica, jprotti@una.ac.cr
2 RSMAS, University of Miami, USA.
3 University of California, Santa Cruz, USA.
4 PennState University, USA.
5 ERI, University of Tokyo, Japan.
6 Central Washington University, USA.

The first slow earthquake ever reported in Costa Rica began in mid-September 2003 and lasted about 4 weeks. Reprocessing of the data from the continuously recording, three-station, GPS network of the time on the Nicoya Peninsula, Costa Rica, shows that at least one more slow event occurred earlier that year. Only the September 2003 event was large enough to be well recorded. Continuous GPS (CGPS) data from four sites was processed with the Gipsy-Oasis II software utilizing satellite orbit and clock parameters provided by JPL. Point positioning and precise orbits and clocks were used to analyze the phase data with ambiguity resolution applied. Daily positions and covariance matrices were determined within the ITRF2000 reference frame using daily frame products also from JPL. Final time series were simultaneously detrended and corrected for hardware upgrades, earthquakes, and annual and semi-annual sinusoidal signals caused by mismodeled seasonal effects. The slow seismic activity recorded is occurring along a portion of the subduction zone in NW Costa Rica, under and around the Nicoya peninsula. The Nicoya segment of the Middle America Trench has been recognized as a mature seismic gap with potential to generate an Mw>7.5 earthquake in the near future (it ruptured with large earthquakes in 1853, 1900 and 1950). These large events together with GPS results from campaigns in the region indicate around 50% of seismic coupling for large fast rupturing events, leaving about half of the potential slip from convergence to slide by means of slow earthquakes. Recording of the September 2003 slow earthquake helped get funding to construct and install a 13 CGPS network on the Nicoya peninsula. With this network we were able to record another slow event that occurred in May 2008.

We will present details for each of the recorded slow earthquakes and will show the complete geodynamic network on the Nicoya peninsula, jointly funded and operated by the US, Japan and Costa Rica.

Volcan Nevado de Huila (Colombia): Erupción y lahar del 20 de noviembre 2008

Pulgarín B 1), Cardona C 1, Santacoloma C 1, Trujillo N 1, Bolaños R 1, Narváez A 1, Monsalve ML 1, Agudelo A 1, Calvache M 2, Manzo O 1

1 INGEOMINAS, Observatorio Vulcanológico y Sismológico de Popayán, bpulgarin@ingeominas.gov.co2
2 INGEOMINAS, Subdirección de Amenazas Geológicas, Bogotá

El Volcán Nevado del Huila (Pulgarín et al. 2001, Correa & Pulgarín, 2002), con 5364 msnm, está ubicado sobre la Cordillera Central de Colombia, en límites entre los departamentos de Cauca, Huila y Tolima. Es un estrato volcán de composición andesítica, dominantemente efusivo. Su cima, conformada por varios picos nevados (Pulgarín et al., 2007), está cubierta por un glaciar que a inicios del año 2007 tenía 11 km^2 aproximadamente (Worni, 2007; Pulgarín et al., 2008), el cual ha ido disminuyendo más drásticamente desde que el volcán hizo sus primeras erupciones históricas en Febrero y Abril del año 2007 (Pulgarín et al., 2008a), ya que el glaciar ha sido afectado directamente por las erupciones y se han generado lahares desde su cima hacia sus partes bajas y lejanas a lo largo del río Páez. Luego de haber permanecido con una actividad sísmica relativamente relajada (aunque con algunos episodios más fuertes) después de las erupciones del 2007, la actividad sísmica registrada en el volcán Nevado del Huila en el transcurso del mes de Noviembre de 2008, se caracterizó por el incremento rápido en la ocurrencia de eventos relacionados con tránsito de fluidos a través de los conductos del edificio volcánico y en algunos casos se pudo asociar dicho registro con emisiones de gas y ceniza (INGEOMINAS, 2008) y algunos cambios morfológicos sobre la cima del Pico Central del volcán.

En los primeros días del mes de Noviembre se registraron eventos de disparos sísmicos con movimiento y tránsito de fluidos, los cuales finalizaron con pulsos de tremor de baja frecuencia (noviembre 2 a las 01:35, 04:13 y 20:26 y noviembre 3 a las 05:30 y 07:20 hora local). Posteriormente a la ocurrencia de estos eventos, sucedieron pulsos de tremor espasmódicos de baja frecuencia. Dicha actividad está relacionada con pequeñas emisiones de material hacia superficie. Luego, en la mañana del día 07 se registró un cambio en el comportamiento sísmico del complejo volcánico, representado por el registro de un tremor continuo de baja frecuencia que se prolongó por cerca de 5 horas; este tremor se inició a las 08:27 hora local y probablemente estuvo asociado con emisiones de ceniza y gases a superficie, este proceso se caracterizó por presentar frecuencias dominantes entre 1.2 y 1.7 Hz, obteniéndose desplazamientos reducidos entre 8.5 y 13 cm^2 para ondas de cuerpo y de 4 a 5 cm^2 para ondas de superficie. Esta actividad dio paso a un aumento significativamente predominante de eventos tipo Largo Período (LP) e Híbridos (HB) en el Pico Central, a niveles muy someros de profundidad, entre el 8 y el 20 de noviembre, con un total de 17564 eventos, los cuales presentaron una

frecuencia dominante característica y consistente de 1.7 Hz y una subdominante de 2.5 Hz, los desplazamientos reducidos oscilaron entre 25 cm^2 y 97cm^2 para ondas de cuerpo y entre 10 cm^2 y 40 cm^2 para ondas superficiales; lo anterior se relacionó con la migración de un cuerpo magmático hacia superficie, que al interactuar con el sistema hidrotermal generó emisiones continuas de gases y ceniza. Al continuar el proceso en su evolución, persistió la ocurrencia de eventos en gran cantidad, de tal manera que alcanzó un promedio diario de 1210 sismos hasta el día 20 en horas de la tarde. A las 21:45 horas, tiempo local, del mismo día, ocurrió un nuevo evento eruptivo, caracterizado por comenzar con un disparo sísmico de eventos tipo LP, el cual duró 4 minutos aproximadamente y presentó un rango de frecuencias entre 1.8 y 2.0 Hz; a éste le siguió inmediatamente la señal eruptiva que saturó los registros análogo y digital alrededor de 9 minutos, a partir de este momento fue decayendo lentamente la señal para ajustar un total de duración o coda de 28 minutos. La actividad sísmica durante esta erupción tuvo un comportamiento dominante de sismos tipo LP, HB y Tremor (TR), con tiempos de recurrencia muy cortos.

Esta intensa actividad que terminó en una erupción de características freatomagmáticas, el día 20 de Noviembre a las 21:45, produjo la inmediata generación de un lahar primario desde la cima del Pico Central, el cual llegó por el flanco occidental a lo largo de la quebrada Bellavista hasta el río Páez y sobre éste recorrió más de 100 km de distancia, hasta llegar al río Magdalena y posteriormente a la Represa de Betania, donde llegó ya muy diluido y donde fue controlado el caudal de entrada sin causar grandes estragos. Este lahar tuvo alturas de inundación promedio de unos 45 m, 20 m y 5 m, para las partes alta media y baja de su recorrido, respectivamente, a largo del río, con un volumen cercano a los 400 millones de m^3 (similar al ocurrido en junio de 1994 y mayor que el ocurrido en Abril de 2007) y velocidades del orden de 100 km/h en la parte próxima hasta de 20 km/h en su parte lejana. La principal afectación por causa del lahar fue en la población de Belalcázar, localizada a unos 45 km al sur de la cima volcánica a través del río y a unos 32 km en línea recta, en donde la inundación alcanzó entre 19 y 23 m sobre el nivel del río, pero a la vez hubo gran depositación de sedimentos, lo que causó la elevación del lecho del río entre 7 y 11 m.. Posteriormente al evento eruptivo, se observó un decrecimiento notable en la actividad sísmica tanto en número de eventos como en energía de los mismos, debido a la liberación de presiones que experimentó el sistema volcánico después de la erupción. El número de sismos para la última semana de Noviembre de 2008 fue de 1147 eventos asociados a tránsito de fluidos (LP, HB, TR).

Como consecuencia de esta actividad ocurrida en el Pico Central del Volcán Nevado del Huila, se formó sobre su parte glaciar un cráter de unos 500 m de diámetro y sobre éste comenzó a aflorar un domo en el sector ubicado entre el flanco suroeste del Pico Central y el flanco noroeste del Pico Sur, a este nuevo proceso se le han asociado eventos sísmicos de tipo LP, HB y TR, al igual que otros relacionados con fracturamiento de roca o volcano – tectónicos (VT) como el ocurrido el 30 de Noviembre a las 14:11 hora local, cuya magnitud fue de 3.0 en

la escala de Richter, con epicentro a 0.6 km al noreste del Pico Central y profundidad de 1.4 km. Adicionalmente a esta actividad intensa, se han presentado una serie de señales de sismos de baja magnitud en la etapa post-eruptiva, eventos que han sido asociados a pequeños colapsos del domo de lava y no han estado asociadas a salida de ceniza y/o gas a superficie. El desarrollo y crecimiento del domo así como la ampliación del cráter continúan hasta la fecha manteniendo la expectativa sobre la posibilidad de generación de nuevos lahares en caso de colapsos o explosiones del domo, con las posibles consecuencias para las poblaciones asentadas en las orillas del río Páez.

Referencias

Correa A & Pulgarín B (2002) Morfología, estratigrafía y petrografía general del complejo volcánico Nevado del Huila (CVNH) énfasis en el flanco occidental. INGEOMINAS Centro Operativo Popayán Informe Interno 104 p

INGEOMINAS (2008) **I**nforme de actividad del volcán Nevado del Huila en Noviembre de 2008. Observatorio Vulcanológico y Sismológico de Popayán Informe interno 24 p (www.ingeominas.gov.co)

Pulgarín B, Jordan E & Linder W. (2007). Aspectos geológicos y cambio glaciar del volcán Nevado del Huila entre 1961 y 1995. Primera conferencia internacional de cambio climático: impacto en los sistemas de Alta Montaña IDEAM – Universidad de Surich Imprenta Nacional:123-140 Bogotá

Pulgarín B, Correa A, Cepeda H & Ancochea E (2001) Aspectos geológicos del Complejo Volcánico Nevado del Huila (CVNH). VIII Congreso Colombiano de Geología y V Conferencia Colombiana de Geología Ambiental (Memorias Digitales). Manizales Colombia

Pulgarín B, Cardona C, Santacoloma C & Agudelo A (2008) El volcán Nevado del Huila (Colombia) y sus erupciones en el 2007. IX Congreso Geológico de América Central (Abstracts) San José Costa Rica

Pulgarín B, Cardona C, Santacoloma C, Agudelo A, Calvache M & Monsalve M (2008a) Erupciones del Volcán Nevado del l Huila (Colombia) en Febrero y Abril de 2007 y cambios en su masa glaciar. VII encuentro internacional de Investigadores del grupo de trabajo de nieves y hielos Andinos y del Caribe (GTNH) Manizales Colombia (Agosto 26 al 30 de 2008 – Memorias digitales)

Worni R (2008). Volcanic eruption-related impacts on glaciers and modelling of lahars at Nevado del Huila Colombia. Diploma Thesis Departement of Environmental Sciences ETH Zurich

Platinum group elements in ultramafic rocks from the central-south of Chile

Rabbia O, Galdames C, Alfaro G, Hernández L, Miller H

Instituto GEA, Universidad de Concepción, Chile. rabbia@udec.cl

In this work we report the first appearance of platinum group minerals (PGM) along with sulfides as inclusions hosted by chromites in ultramafic rocks from the Paleozoic metamorphic basement of central-south Chile.

The host ultramafic rocks belong to a dismembered ophiolitic-like belt, mainly represented by serpentinites, characterized by coarse-grain partial and totally altered dunites to serpentine (Frutos and Alfaro 1985, 1987, Barra *et al.*, 1998). These rocks are hosted in the Western Series of the Paleozoic metamorphic basament composed mainly by metabasites, metaschists and metacherts. The study area is located at La Cabaña in the Cordillera de Nahuelbuta, Chile (Fig. 1).

The studied samples correspond to disseminated (Fig. 2) and massive chromitites associated to serpentinites. Chemical composition of these chromites revels that the original composition has been affected by serpentinization processes along cracks and borders of grains generating the typical alteration product, the ferritchromite. Most core of chromite grains, however, retained their original chemical composition with high-Cr numbers (Cr/Cr+Al) ranging from 0.65 to 0.90 and relatively low Fe+3 numbers (Fe+3/Cr+Al+Fe+3) lower than 0.10 (Barra *et al.*, 1998).

An additional aqueous fluid activity affecting the ultramafic rocks and chromitites of this area has already been documented and dated (Rabbia et al 1997). This work indicate that hydrothermal infiltration was slightly younger (282 ± 6 Ma; K/Ar in Cr-rich muscovite) than the regional metamorphic event (331 ± 29 Ma; Rb/Sr in whole rock, Hervé et al 1990) dated in a nearby mica schist, and therefore unconnected to the serpentinization event.

The chromite grains have silicate inclusions, mostly altered to serpentine-group minerals, but also non-silicates inclusions were recognized. Although with only a few micron across, the later inclusion-type has high reflectance allowing its rapid detection under optical microscope. Selected inclusions were then analyzed by electron microprobe (EPMA) at the Instituto de Geología Económica Aplicada (Universidad de Concepción). These mineral phases are commonly part of larger Ni sulfide inclusions dominated by Millerite (NiS) and Nickeline or Niccolite (NiAs) (Fig. 3). These PGE occur as micro- inclusions (~2 to 10 micrometers across) in chromite grains far from ferritchromite or cracks. However, preservation of primary compositional and textural features from later hydrothermal events reported in the area is not warranted.

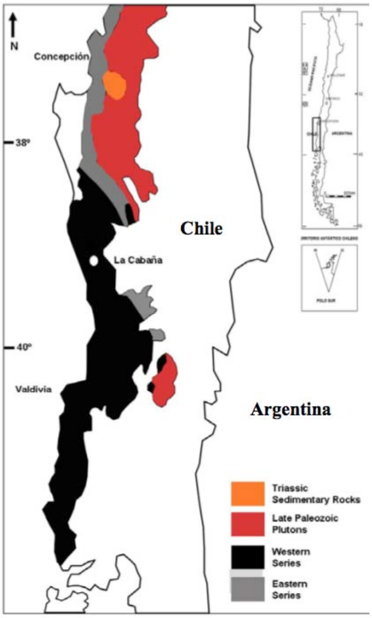


Fig. 1: location of the study area (after Hervé *et al.*, 2007) Chile Argentina et al 1990) dated in a nearby mica schist, and therefore unconnected to the serpentinization event.



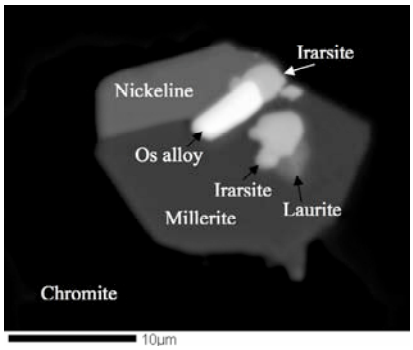


Fig. 2: disseminated chromite grains (black) in La Cabaña serpentinite. Nickeline Irarsite Os alloy Chromite Laurite Millerite Irarsite

Fig. 3: Ni-rich, PGE-bearing composite micro - inclusion in chromite grain from La Cabaña.

The PGM assemblage presents in La Cabaña chromites is concordant with PGM reported from worldwide ophiolitic complexes, like Troodos (Cyprus), Kempirsai (Kazakhstan), Nurali (Russia) among others. The PGE-bearing chromite deposits from these ophiolites has been interpreted as product of basaltic

melt percolation in a supra-subduction zone setting, where the peridotitic mantle would be the source of the Cr and PGE (Büchl *et al.*, 2004; Melcher *et al.*, 1997; Distler *et al.*, 2007; Grieco *et al.*, 2007).

The discovery of the IPGE assemblage in chromitites from the ophiolite complex in the Nahuelbuta cordillera re-open the question of the actual tectonic setting of these ultramafic rocks and its emplacement mechanism in the Paleozoic pre-Andean margin.

References

Barra F, Rabbia O M, Alfaro G, Miller H, Höfer C, Kraus S, (1998) Serpentinitas y cromititas de La Cabaña, Cordillera de la Costa, Chile central. Revista Geológica de Chile 25:29-44

Büchl A, Brügmann G, Batanova VG (2004) Formation of podiform chromitite deposits: implications from PGE abundances and Os isotopic compositions of chromites from the Troodos complex, Cyprus. Chemical Geology 208:217-232

Distler VV, Kryachko VV, Yudovskaya MA (2008) Ore petrology of chromite-PGE mineralization in the Kempirsai ophiolite complex. Mineralogy and Petrology 92:31-58

Frutos J, Alfaro G (1985) El complejo ofiolítico del ámbito eugeosinclinal paleozoico en la cordillera de la Costa del Sur de Chile. IV Congreso Geológico Antofagasta Chile I:332-360

Frutos J, Alfaro G (1987) Metallogenetic and Tectonic chracteristics of the Paleozoic Ophiolitic Belt of the Southern Chile Coast Cordillera. Geologische Rundschau 76:343-356

Grieco G, Diella V, Chaplygina NL, Savelieva GN (2007) Platinum group elements zoning and mineralogy of chromitites from the cumulate sequence of the Nurali massif (Southern Urals, Russia). Ore Geology Reviews 30:257-276

Hervé F, Pankhurst R, Brook M, Alfaro G, Frutos F, Miller H, Schira W and Amstutz G (1990) Rb/Sr geochronology of mineralized sites in the metamorphic basement, South Central Chile. In Stratabound ore deposit in the Andes: Fontboté et al Eds 221-228 Springer-Verlag.

Hervé F, Faundez V, Calderon M, Massone H, Willner A P (2007) Plutonic and metamorphic basament. The Geology of Chile The Geological Society Publishing House UK chap 2:4-19

Rabbia OM, Hernández L, Miller H, Alfaro G (1997) Química mineral de la asociación: Turmalina-Cr, Mica-Cr, Cromita, Cuarzo, presente en el basamento metamórfico del centro sur de Chile. VIII Congreso Geológico Chileno Vol II pag 1468-1472

New U-Pb zircon ages and Nd-Sr isopotic data for igneous and metamorphic rocks from northern Sierra de Comechingones, Argentina

Rabbia O 1, Demichelis A 2, Otamendi J 2,3, Tibaldi A 2,3

1 Instituto GEA, Universidad de Concepción, Chile, rabbia@udec.cl
2 Departamento de Geología, Universidad Nacional de Río Cuarto, Argentina
3 CONICET, Argentina

New U-Pb zircon ages along with $^{143}Nd/^{144}Nd$ and $^{87}Sr/^{86}Sr$ isotope ratios are presented for metagreywackes, belonging to the supracrustal sequence that forms the basement of Sierras de Comechingones (31° 30´ and 32° 30´ S latitude) from central Argentina (Fig. 1). The same isotope ratios for igneous rocks from the same area are also reported. U-Pb zircon dating was done on four samples including migmatite, and gneises with different mylonitization grades, from Athos Pampa and Villa Berna areas (insert Fig 1). Spot analyses (beam size of ~15-20 x 30 microns), 62 in total, were performed by SHRIMP at UCLA (USA).

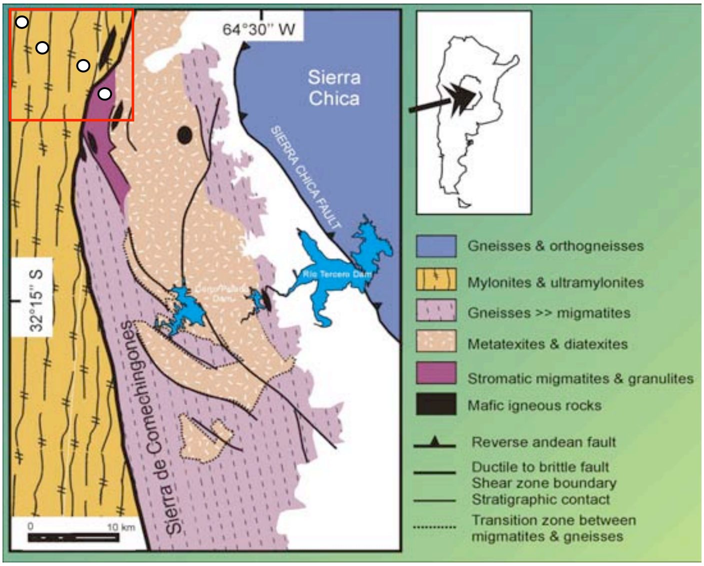


Fig. 1. Location map of the study area (red box) and distribution of dated zircon samples (open circles). After Otamendi et al (2003).

Cathodoluminescence and back-scattered electron images show that many of the zircons from all four samples have metamorphic over-growths (Fig. 2). All four samples show a peak in their cumulative age histograms at 536-565 Ma plus a variety of Neo-proterozoic inherited core ages, many concordant but a few very old discordant ages up to ~2.1 Ga. The ages in these samples increase systematically toward west. The resulting metamorphic ages are close to but slightly older than those obtained in previous works (e.g. Rapela et al 1998;

Sims et al 1998). The intrusion of the Achala granite batholite occurred at ~390 Ma and located nearby the study area toward the west (not shown in Fig 1) had no effect on existing zircons from studied samples. On the other hand, isotope ratios were determined in gneisses from the La Calera and Río Quillinzo areas, located to the west of the Río Santa Rosa granulates, as well as in igneous rocks from Río Grande, Suya Taco, Inti Yaco mafic bodies.

Metamorphic rocks derived from a sedimentary protolith, show high but variables $^{87}Sr/^{86}Sr$ $_{(t=525\text{-}565\ ma)}$ ratios, from about 0.7069 to 0.7189. The εNd $_{(t=525\text{-}565\ ma)}$ for the same simples ranges from -4.1 to -5.5. The high grade rocks from the Río Santa Rosa granulites are the less evolved from the isotopic point of view.

The mafic igneous rocks and associated charnokites (see Tibaldi et al 2008) shows distinctive but variables isotope ratios. The less hybridized mafic samples have lower $^{87}Sr/^{86}Sr$ ratios (> 0.7032) and higher $\varepsilon Nd_{(520\ ma)}$ (< +3) than the gneisses. The more evolved/hybridized mafic rocks are more radiogenic than the formers ($^{87}Sr/^{86}Sr$ (t) up to about 0.7047 and εNd lower than -0.4).

The new U-Pb zircon ages of metasedimentary rocks from northern Sierra de Comechingones suggest that the onset of the Pampean Orogeny is older than previously determined (e.g. ~540 Ma, Sims et al 1998) allowing to extend the protracted thermal history of this orogeny back to Neoproterozoic times. The isotope composition of mafic igneous rocks (e.g. $^{87}Sr/^{86}Sr_t$ 0.7032 – 0.7044) clearly reflects the degree of interaction (assimilation/hybridization) with the more radiogenic field gneisses (e.g. $^{87}Sr/^{86}Sr_t$ >0.7128). The Río Santa Rosa Granulites, however, are in between the above two isotopic end members (e.g. $^{87}Sr/^{86}Sr_t$ 0.7069 to 0.7075).

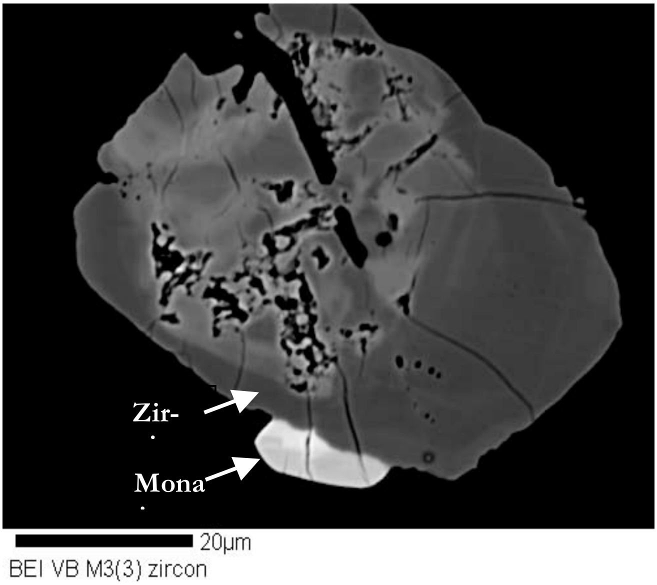


Fig. 2. Backscattered electron image of zircon showing an irregular core (light grey) and an overgrowth rim (drack gray, indicated). A metamorphic monazite grain is attached to the zircon (bright whitish grey, bottom-centre, indicated).

References

Otamendi JE. Demichelis AH, Tibaldi AM, Rabbia OM (2003) Origin of garnet-orthopyroxene- bearing granulites: evidences from the granulites from northern Sierra de Comechingones, Argentina. Congreso Geológico Chileno, Concepción

Rapela CW, Pankhurst RJ, Casquet C, Baldo E, Saavedra J, Galindo C, Fanning CM (1998) The Pampean Orogeny of the southern proto-Andes: Cambrian continental collision in the Sierras de Córdoba. In Pankhurst RJ, Rapela CW (Eds) The Proto-Andean Margin of Gondwana. Geological Society of London Special Publication 142:181-217

Sims JP. Irreland TR. Camacho A. Lyons P. Pieters PE. Skirrow RG. Stuart-Smith PG. Miró R (1998) U-Pb, Th-Pb and Ar-Ar geochronology from the southern Sierras Pampeanas, Argentina: implication for the Palaeozoic tectonic evolution of the western Gondwana margin. Geological Society of London Special Publication 142:259-281

Tibaldi AM, Otamendi JE, Gromet LP, Demichelis AH (2008) Suya Taco and Sol de Mayo mafic complexes from eastern Sierras Pampeanas, Argentina: Evidence for the emplacement of primitive OIB-like magmas into deep crustal levels at a late stage of the Pampean orogeny. Journal of South American Earth Sciences 26:172–187

Paleozoic Granjeno Schist and its implications in the evolution of the basement of the Sierra Madre Oriental, NE Mexico

Ramírez-Fernández JA, Torres-Sánchez SA, Cossío-Torres T

Facultad de Ciencias de la Tierra, Universidad Autónoma de Nuevo León, Hacienda de Guadalupe, AP 104, 67700 Linares, N.L.

The basement of the Sierra Madre Oriental (SMO) is well exposed in the core of the laramidic Huizachal-Peregrina Anticlinorium near Ciudad Victoria. It comprises 4 contrasting units: Grenville-age Novillo Gneis (~1 Ga), Paleozoic Granjeno Schist (~ 300 Ma), leucocratic Tonalite (~350 Ma) and a Silurian to Permian deformed sedimentary sequence. They are NW-SE oriented and in tectonic contact through vertical faults. The basement is covered by a very thick Mesozoic sedimentary column mainly constituted by red beds, evaporites, limestones and shales.

Granjeno schist (GS) outcrops particularly in the Novillo, Peregrina and Caballeros canyons. It is important to note that in Caballeros Canyon the lithology is more restricted to pelitc and psamitic varities than i.e. in Novillo Canyon that displays a huge variation of lithologies: pelitic, psamitic, silicic, graphitic, volcanoclastic and metaigneous.

A GS narrow (~1.6 km) NW-SE trending band is exposed in the Caballeros Canyon. Here the schist is massive, greenish, gray to black, with interstratifications of pelitic to psammitic lithologies. The present mineralogy is: quartz, muscovite, albite, graphite, chlorite, biotite, and garnet. It is easy to recognize the differences between these lithologies, because the pelitic levels are strongly deformed, where at least three foliations that affected the GS unit are well preserved. The dominat directions of these schistosities are 150º/55º, 320º/60º and 99º/58º, respectively.

These schistosities are represented by F1 that is the earliest deformation and is recognized by quartz folded segregation, these should be firstly parallel to the original bedding protholit, F2 that is the most pervasive schistosity in the whole. During F2 quartz segregations developed in a second generation, folds (some of them with vertical axial planes) and F3 that is lesser developed and penetrative with the formation of kinks, box folds, crenulation of graphitic layers structures and oblique segregations to F2.

In contrast, psammitic beds are more competent, lighter in color, and display generally only the most pervasive foliation F2. Quartz is more abundant than in the pelitic units, forming boudinage structures and folded segregations. In this lithology a later deformation phase is documented; it is represented by folds with mostly vertical axes, that fold the other three deformations on his limbs and axes. In the psammitic bedes different generations of faulting, like normal and lateral are good preserved. The radiometric age ranges from 330 – 257 Ma (K/Ar, Rb/Sr), and the PT conditions varies from 300-600 MPa and 350-400 ºC (Czerna & Ortega-Gutiérrez, 1978; Garrison, 1978; Ramírez-Ramírez, 1992; Ortega Gutiérrez, 1993, Dowe et al., 2005). According to Castillo (1988) the metamorphism is low grade, high pressure greenschist facies.

The GS lithology is the result of the metamorphism mainly of a sequence of pelitic and psammitic sediments. They were deposited in a deep basin partially under euxinic conditions represented by graphitic schists and with the irregular influx of turbiditic currents by psammitic beds. Possibly the basin were located near the continental talus, between the continental masses of Laurussia and Gondwana, in the Rheic Ocean (Nance & Linneman, 2008). The GS metamorphism could represent vestiges of the closure of the Rheic Ocean during the latest stages of the formation of Pangea.

References

Castillo-Rodríguez H (1988) Zur Geologie des kristallinen Grundgebirges der Sierra Madre Oriental insbesodere des Granjeno Schiefer Komplejes in Südteil des Huizachal Peregrina Antiklinoriums Raum Cd. Victoria Tamaulipas Mexiko. Univ. Münster Unveröff Diplomarbeit

Cserna Z, Ortega-Gutiérrez F, (1978) Reinterpretación tectónica del Esquisto Granjeno Cd. Victoria, Tamaulipas Contestación. Universidad Nacional Autónoma de México Revista del Instituto de Geología v2 p 212-215

Dowe DS, Nance RD, Keppie JD, Cameron, KL, Ortega-Rivera, A, Ortega-Gutiérrez F, Lee JWK, (2005) Deformational history of the Granjeno Schist Ciudad Victoria México constraints on the closure of the Rheic Ocean? Int Geol Rev v47 p 920-937

Garrison JR, (1978) Reinterpretation of isotopic age data from the Granjeno Schist Ciudad Victoria Tamaulipas Revista del Instituto de Geología Universidad Nacional Autónoma de Mexico v2 p 87-89

Nance RD, Linneman U (2008) The Rheic Ocean Origin Evolution and Significance. GSA Today Geological Society of America v18 p 4-12

Ortega-Gutiérrez, F, Centeno-García E, Morán Centeno DJ, Gómez, Caballero A (1993) Pre-Mesozoic Basement of NE Mexico lower crust and mantle xenoliths of central Mexico and Northern Guerrero terrane in Field Trip Guideboork A Proceeding 1st Circum Pacific and Circum Atlantic Terrene Conference Guanajuato Mexico Univ. Nacional Autónoma de Mexico Inst. Geología p 96

Ramírez-Ramírez C (1992) Pre-Mesozoic geology of Huizachal Peregrina Anticlinorium Ciudad Victoria Tamaulipas and adjacent parts of eastern Mexico Granjeno Schist. Unpubl PhD thesis University of Texas Austin 317 p

---

Nejapa Tephra: The youngest (c. 1 ka BP) highly explosive hydroclastic basaltic eruption in western Managua (Nicaragua)

Rausch J, Schmincke H-U

IFM-GEOMAR, Wischhofstr. 1-3, 24148 Kiel, Germany Juanita.Rausch@gmx.de

Nejapa maar (2.5 x 1.4 km, c. 120 m deep), the largest maar along the 15 km long Holocene Nejapa Miraflores Lineament (NML), is unequivocally the source vent of the youngest widespread basaltic tholeiitic tephra blanket (Nejapa Tephra: NT) in western central Nicaragua, as shown by isopachs and isopleths (Rausch and Schmincke, 2008). Pardo et al. (2008) related the same deposits to Asososca maar which we infer to be the source of an older tephra deposit. The NT covers an area of >10 km² in western/northwestern Managua. The minimum total magma volume erupted is estimated as >0.1 km³. Juvenile, dominantly slightly vesicular (20-40 vol. %), basically tachylitic cauliflower-shaped lapilli with an average density of 2.1 g/cm³ make up >90 vol. % of the deposit, while lithics generally comprise <1 vol. % except in the proximal facies of the southern and northern fan. This, the paucity of fine-grained tuffs and the dominant plane-parallel bedding all suggest fragmentation by shallow interaction of a pyroclastically pre-fragmented magma with external water, eruption in moderately high eruption columns (~ 7-10 km) and dominant deposition as dry to damp, warm to cool fallout. Surge transport is evident in fine-grained locally cross-bedded tephra beds that are most common in an elongate depression north of Nejapa maar and just west of Asososca maar. Synvolcanic faulting along the NML is inferred. Faults mapped in the study area indicate that the activation of the N-S trending Nejapa Miraflores Fault (NMF),

representing the western flank of Managua graben, preceded deposition of NT and underlying Masaya Tuff (1.8 ka BP), Chiltepe Pumice (1.9 ka BP) and Masaya Triple Layer (2.1 ka BP) (Kutterolf et al., 2007; Pérez and Freundt, 2006; Pérez et al., 2008). Dike intrusion and faulting along the NML are probably related processes and faulting may have facilitated diking and vice versa. The NT-deposit is underlain by a regional paleosol and topped by a soil. The basal paleosol contains pottery sherds made by the Usulután negative technique during the Late Formative period (700 BCE-300 CE) (2.7-1.7 ka BP). The soil overlying NT contains pottery related to the Ometepe technique dated as between 1 350 and 1 550 CE (650-450 a BP) (Garcia pers. comm.). These, and the radiocarbon dates of the pottery-bearing paleosoils (1 245 ± 125 and 535 ± 110 a BP) obtained by Pardo et al. (2008) infer an age between 1.2 and 0.6 ka for the NT.

The recurrence of an eruption of this magnitude at Nejapa maar or a neighboring site and similar eruptive and transport mechanisms would represent a major hazard and risk to the densely populated western suburb of Managua, a city that is expanding rapidly towards the west. In view of the past frequency of eruptions along the NML, further eruptions are likely in the near future (Freundt at al, 2006a). Assuming a similar magnitude and evolution of eruption such as Nejapa eruption, low-quality roofs, common in Nicaragua, are prone to collapse up to 12 km peripheral to Nejapa maar or another close-by eruptive site, and buildings at a distance of up to 500 m are likely to be severely affected.

References

Freundt A, Kutterolf S, Schmincke HU, Hansteen TH, Wehrmann H, Pérez W, Strauch W, Navarro M (2006a) Volcanic hazards in Nicaragua: past, present, and future. In: Rose WI, Bluth GJS, Carr MJ, Ewert J, Patino LC, Vallance JW (eds.) Volcanic hazards in Central America Geol Soc Am Spec Publ,: 141–165

Kutterolf S, Freundt A, Pérez W, Wehrmann H, Schmincke, H-U (2007) Late Pleistocene to Holocene temporal succession and magnitudes of highly-explosive volcanic eruptions in west-central Nicaragua. J Volcanol Geotherm Res 163: 55-82

Pardo N, Avellán DR, Macías JL, Scolamacchia T, Rodriguez D (2008) The ~1245 yr BP Asososca maar: new advances on recent volcanic stratigraphy of Managua (Nicaragua) and hazard implications. J Volcanol Geotherm Res 176: 493-512

Pérez W, Freundt A (2006) The youngest highly explosive basaltic eruptions from Masaya Caldera (Nicaragua): Stratigraphy and hazard assessment. In: Rose WI, Bluth GJS, Carr MJ, Ewert J, Patino LC, Vallance JW (eds) Volcanic Hazards in Central America. Geol Soc Am Spec Publ: 189-207

Pérez W, Freundt A, Kutterolf S, Schmincke HU (2008) The Masaya Triple Layer: a 2100 year old basaltic multi-episodic Plinian eruption from the Masaya Caldera Complex (Nicaragua). J Volcanol Geotherm Res 179: 191-205

Rausch J, Schmincke H-U (2008) Nejapa Tephra: The youngest (c. 1 ka BP) highly explosive hydroclastic basaltic eruption in western Managua (Nicaragua). Shaker Verlag, pp 1-72

Provenance of K/P sandstones from NE-Mexico

Rehrmann S, Augustsson C

Geologisch-Paläontologisches Institut, Correnssstrasse 24, 48149 Münster, Germany st.rehrmann@gmx.de

In an ongoing provenance study, two sedimentary sections in NE Mexico containing sandstones presumably related to the Chicxulub impact at the K/P boundary are analysed. El Cerrito in Linares (24°52'N 99°33'W, ca. 120 km SE of Monterrey), a hitherto undescribed sedimentological section comprising the uppermost Maastrichtian is compared to the better known El Peñón K/P profile ca. 35 km east of Linares (24°58'N 99°13'W). Due to the assumption that the sediments are tsunami-related, the complete sandstone section of ca. 10 m would be expected to be composed of sand recycled from shallow shelf and coastal areas of the Mexican Gulf. The study should reveal if provenance changes and differences occur within and between the sandstone sections. The sandstones of both geological sections overlay marine limestone and marl of Maastrichtian age. At El Peñón two spherule layers composed of impact material related to the Chicxulub K/P impact are situated between the marl and the sandstone. The sandstones in both studied geological sections generally are fine- to medium-grained with a carbonate cement. The sand particles are composed of 75-95 %, quartz, < 15 % feldspar. Lithic fragments are rare and of sedimentary origin. Of the total quartz fraction, 60-75 % are monocrystalline particles. Of these, 65-80 % are non-undulous and up to 35 % are undulous. Our first results point to mineralogically mature sandstones. The sedimentary lithic fragments indicate a certain degree of sedimentary recycling. The occurrence of undulatory quartz grains indicate a certain influence from metamorphic source rocks. A first assumption is that the material could be ultimately derived from the Precambrian / Palaeozoic North American crystalline craton to the north or from mainly Mesozoic sedimentary rocks from the Sierra Madre Oriental to the west. Further investigations will focus on cathodoluminescence spectra of detrital quartz grains and on heavy mineral analysis of the sandstones. With the analyses we hope to detect any occurring provenance changes between and within the El Cerrito and the El Peñón sections.

Sedimentological and paleontological overview over the coastline of Mocha Island (south-central Chile)

Reich S, Nielsen SN

Institut für Geowissenschaften, Christian-Albrechts-Universität zu Kiel, Germany, reich@gpi.uni-kiel.de

Mocha is a 52 km2 large island located 35 km from the coast opposite the town Tirúa (200 km south of Concepción). During a field-campaign in November 2008 the coastline has been mapped and fossil samples, mainly gastropods and bivalves, were collected. The sediments of the coastline of Mocha Island are divided into 6 units of marine sand- and siltstones differing in lithology. The deposits are partly covered by Quaternary sandy beach sediments. The sedimentary units can be put into a rough stratigraphic context based on the available literature (Tavera & Veyl 1953), comparison with outcrops of the mainland (Ranquil and Tubul Formations, Arauco Peninsula) and molluscan macrofossils. They are supposedly of Miocene to Pliocene age except for a relatively small outcrop of presumably Eocene sandstone (unit 1) on Isla de Las Docas located at the south-western tip of Mocha Island. Oligocene deposits are unknown from the sedimentary record of the area (Schöning & Bandel 2004). Units 2 and 3 have been assigned to the Miocene. Siltstone outcrops of unit 2 occur rarely in the intertidal zone, but rip-up clasts and reworked macrofossils are found in overlying massive conglomerates of unit 3. These fossils represent a fauna also known from the Ranquil Formation, containing the deep-water taxa *Dalium, Exilia* and *Struthiochenopus* (Finger et al. 2007). Besides of the massive conglomerates, unit 2 also contains a sandstone-facies showing a high variability of sedimentary structures including micro-tectonic structures and the trace-fossil *Zoophycos.*

Units 4, 5 and 6 contain a very similar fauna and have been assigned to the Mio-Pliocene. The fossil record is rich: 12 bivalve and 19 gastropod taxa, including new species, have been collected in the sandstones of unit 6. *Incatella chilensis* and *Chione chiloensis* are the most abundant taxa in units 5 and 6. *Chlamys chilensis* is very common in the sandy siltstones of unit 4. Other gastropod-taxa found in unit 6 are *Acanthina, Crepidula, Distorsio, Nassarius* and *Penion* representing intertidal and/or shallow water conditions (Finger et al. 2007). Barnacles incrusting gastropod shells have been found as well. These faunal elements together with the coarsening upward sediments from unit 1 to unit 6 reflect a change from deep to shallow water conditions during the late Miocene.

The mountainous centre of the island consists of marine Plio-Pleistocene sandstone assigned to the Tubul Formation. The flatland between the coastal zone and the mountains is covered by Quaternary sediments. Further work on the stratigraphy of Mocha Island based on planktic foraminifera and $^{87}Sr/^{86}Sr$-dating of mollusk shells is in progress.

References

Finger KL, Nielsen SN, DeVries TJ, Encinas A, Peterson DE (2007) Paleontologic evidence for sedimentary displacement in Neogene forearc basins of central Chile. Palaios 22: 3-16

Schöning M, Bandel K (2004) A diverse assemblage of fossil hardwood from the upper tertiary (Miocene?) of the Arauco Peninsula, Chile. Journal of South American Earth Sciences 17: 59-71

Tavera J, Veyl C (1958) Reconocimiento geológico de la Isla Mocha. Anales de la Facultad de Ciencias Físicas y Matemáticas 14-15: 157-186

Provenance of Ordovician and Devonian sandstones from southern Peru and northern Bolivia - U-Pb and Lu-Hf isotope evidence of detrital zircons and its implications for the geodynamic evolution of the Western Gondwana margin (14°-17°S)

Reimann CR 1, Bahlburg H 1, Kooijman E 2, Berndt J 2, Gerdes A 3, Carlotto V4

1 Institut für Geologie und Paläontologie, Westfälische Wilhelms Universität Münster, reimannc@uni-muenster.de, bahlbur@uni-muenster.de

2 Institut für Mineralogie, Westfälische Wilhelms Universität Münster

3 Institut für Geowissenschaften, Mineralogie, J.W.Goethe Universität Frankfurt,

4 INGEMMET, Lima, Perú

In an attempt to trace the provenance of sedimentary detritus and to gain information on the crustal evolution of the Early Paleozoic western Gondwana margin (14°-17°S) we applied a combined *in situ* U-Pb and Lu-Hf LA-ICP-MS isotope analysis on detrital zircon from 12 Ordovician and Devonian sandstones in southern Peru and northern Bolivia.

The sandstones are exposed in the Eastern Cordillera, the Altiplano and the Coastal Cordillera. The sedimentary basins are part of the Peru-Bolivia trough. Few intrusive and extrusive Early Paleozoic rocks indicate that the Ordovician basins developed in a back-arc position, with the arc on the Arequipa Massif in the west and the Amazonian craton in the east. This plate-tectonic setting appears to have changed into a passive margin in the Early Devonian.

The U-Pb zircon age distribution of the Ordovician sandstones from the Eastern Cordillera has the most distinctive peak between 0.7 and 0.5 Ga (Brazilian interval). Contrastingly, the most prominent U-Pb zircon age peak of the Ordovician sandstones from the Altiplano is at 1.2-0.9 Ga (Grenvillian interval) with a smaller peak at 1.85-1.7 Ga. The Devonian sandstones from the same locality on the Altiplano contain zircons with a major age peak at 0.5-0.4 Ga (Famatinian interval). Smaller U-Pb age peaks can be connected to the Brazilian, Grenvillian and Transamazonian (2.2-1.8 Ga) intervals. Zircons of the Devonian sandstones from the Coastal Cordillera have a similar age distribution but the Grenvillian ages, in one case also the Transamazonian ages are significantly more pronounced than the Brazilian ages.

Zircons formed during the Brazilian interval could have been derived from various eastern sources on the Amazonian craton, those with Grenvillian ages were derived either from the Sunsas belt to the east or from the Arequipa Massif to the west of the sedimentary basin. Zircons related to the Famatinan event most probably originated in the Arequipa Massif, the closest place where respective magmatic arc rocks were available. Thus, the Ordovician sandstones of the Eastern Cordillera and the Altiplano had an eastern source, while the Altiplano locality was fed from a very limited source area, probably the Sunsas belt. The Devonian siliciclastic strata instead were mainly influenced by the Arequipa Massif. Minor influences of eastern sources are documented by the presence of Brazilian zircon ages.

The *in situ* Lu-Hf isotope signature provides information about crustal recycling. Together with the U-Pb zircon ages, crustal evolution paths can be reconstructed. εHf(t) values of the analysed zircons spread between –20 and +12. Zircons with a very juvenile signatures (less than 5 εHf-units below the respective depleted mantle composition) we detected only in the interval between 1.5 and 0.9 Ga. Hence, of the Brazilian and Famatinian events we only find zircons derived from an evolved crust. A striking feature is the common Hf model ages (c.1.5-1.2 Ga) of zircons formed during the Grenvillian, Brazilian and Famatinian orogenies. This indicates that Famatinian-aged crystalline rocks of the Arequipa Massif and the Brazilian-aged crystalline rocks of the Amazonian craton have a similar crustal origin.

Contaminacion de aguas subterranes, Sub Cuenca Oriental del Acuífero de Managua: Determinación de zonas de captura para pozos de Bombeo

de los Ángeles Hernández Calero R

Ingeniero Civil. MSc Recursos Hídricos. Investigador en el Centro de Investigaciones y Estudios en Medio Ambiente de la Universidad Nacional de Ingeniería, CIEMA-UNI.

Para Managua, la capital, las aguas subterráneas son la fuente más importante ya que se abastece casi en su totalidad de ellas. El acuífero de Managua esta dividido en tres subcuencas: La Oriental, Central y Occidental. La sub cuenca oriental y central su extensión es de unos 680 km² de los 1040 Km² que tiene el acuífero. La oriental es la más extensa de las tres subcuencas y su importancia está basada en que tiene la zona de mayor recarga del acuífero, el grado de complejidad hidrogeológica por encontrarse en ella el complejo volcánico Masaya, que esta ubicado en la parte sur de la sub cuenca que cubre una parte de la recarga, fallamientos geológicos de importancia como la de Cofradía en la parte norte del área, campos de pozos de importancia como el Managua I (campos de pozos de Ticuantepe), Managua II (campo de pozos camino a Sabana Grande) y el campo de pozos Las

Mercedes. Con asesoría de la KTH se construyo el modelo matemático de la Cuenca Oriental del acuífero de Managua, el cual se puede utilizar para simular situaciones de contaminación del agua subterránea en la cuenca en estudio. El software que se esta utilizando para la realización de esta modelación es el FLOW-PATH II para Windows, diseñado para simular flujo y transporte de contaminantes en dos dimensiones de aguas subterráneas en acuíferos libres, confinado y semi - confinado con propiedades heterogéneas, con múltiples pozos de bombeos y complejas condiciones de frontera.

Objetivos de la modelación:
- Construir un modelo hidrogeológico de la cuenca oriental del acuífero de Managua que sea utilizado para una mejor comprensión del comportamiento del sistema subterráneo en el área de estudio.
- Simular arrates de partículas para la protección de pozos en la cuenca Oriental del acuífero de Managua.

Materiales y Métodos:
- Recopilación de toda la información existente (Estudios, pruebas de bombeos, datos de niveles dinámicos, geometría del acuífero, datos de campo en algunos casos como la actualización de niveles dinámicos) y las instituciones que suministran la información son INETER, ENACAL entre otros)
- Entrevistas con profesionales de reconocida experiencia en el tema en el país. Información que sirve de apoyo para la interpretación del sistema.
- Informe del estudio Abastecimiento para la ciudad de Managua-JICA.1993
- Interpretación del funcionamiento del sistema entre varios profesionales con apoyo de la KTH de Estocolmo, Suecia.
- Construcción del modelo conceptual.
- Construcción del modelo matemático.

Resultados y discusión: Se ha construido el modelo en base a la información existente de ENACAL e INETER y se ha realizado algunos cálculos como la Recarga, (los valores de Recarga se han calculado en base a la isoyetas del año 1999, datos de porcentaje de infiltración de acuerdo a la topografía y una combinación con el material geológico). Obteniendo así valores de recarga para diferentes tipos de materiales geológicos. Los valores de Permeabilidad han sido asumidos de acuerdo a la información de estudios y la experiencia de profesionales expertos.

La dirección del flujo sigue aproximadamente el gradiente hidráulico y además ya me indica las rutas preferenciales del agua subterránea. Para su calibración sé esta calibrando en base a un parámetro (Conductividad) en esta primera fase. Calibración con conductividad y comportamiento de isofreatas.

Conclusiones: La dirección del flujo es de Sur a Norte descargando en el lago y parte del mismo en la zona de recarga se infiltra en el complejo volcánico Masaya siguiendo su descarga en dirección del lago.

Ha servido para seleccionar toda la información valida para efectos de modelación la cual se ha compilado. La utilización del software Flowpath II para Windows es valida para la información existente y da buenos resultados. Se han simulado arrastres de partículas y transporte de contaminantes en el área de estudio.

Ocean tides and sea-level changes derived from tide gauge measurements in the Beagle Channel, Tierra del Fuego

Richter A 1, Hormaechea JL 2, Dietrich R 1, Del Cogliano D 3, Mendoza L 3, Connon G 2, Perdomo R 3, Fritsche M 1, Guerrero R 4

1 TU Dresden, Institut für Planetare Geodäsie, Germany richter@ipg.geo.tu-dresden.de
2 Estación Astronómica Río Grande, Argentina
3 UNLP, Facultad de Ciencias Astronómicas y Geofísicas, La Plata, Argentina
4 INIDEP, Mar del Plata, Argentina

The narrow Beagle Channel in Tierra del Fuego, southernmost South America, is not included in global ocean tide models such as FES2004. Therefore, tide gauge observations in the channel are of particular value for the understanding of the tidal hydrodynamics between the Atlantic and Pacific oceans in this region.

A pressure tide gauge was operated at Harberton on the northern shore of the Beagle Channel from February 2005 for almost one year. The instrument was moored on the sea floor in a depth of 10 m. Based on these data a continuous sea-level record was derived with an estimated accuracy better than 1 cm for a single value. The tidal signal was extracted from the recorded sea-level variations by a harmonic analysis. As a result, the harmonic constants for 16 constituents were determined along with estimates of their accuracy.

Two additional tide gauges were included in the analysis in order to obtain insights into the propagation of the tidal waves through the Beagle Channel. A tidal analysis of available tide gauge data from Ushuaia (Argentina) and Puerto Williams (Chile) yielded tidal parameters for both locations which are compared with the results for Harberton. The consistency of the obtained picture of the tidal wave propagation with a global ocean tide model at either ends of the Beagle Channel is discussed. In addition to diurnal and semi-diurnal constituents, the occurrence of shallow-water tides is addressed.

Non-tidal sea-level variations are investigated on the basis of the residual record from Harberton. The inverse barometer effect as the dominating form of atmospherically driven variations is quantified through the correlation of the sea-level changes with air pressure variations.

Finally, the water temperature and salinity time series recorded by the Harberton tide gauge are presented. A few geophysical and oceanographical implications of the obtained results are outlined.

Structure at the retroarc zone between 37º and 39ºS based on gravimetric, magnetometric, seismic and field constraints: The Loncopué trough

Rojas Vera E 1, Folguera A 1, Zamora Valcarce G 2, Gímenez M 3, Ruiz F 3, Martínez P 3, Bottesi G 4, Ramos VA 1

1 Laboratorio de Tectónica Andina. Universidad de Buenos Aires, emilio@gl.fcen.uba.ar
2 Repsol- YPF. España.
3 Instituto de geofísica Volponi. Universidad de San Juan.
4 Repsol-YPF. Argentina

The Loncopué trough is located between 36º30´and 39ºS, interposed between the Agrio fold and thrust belt, where older compressional deformations were produced in the Late Cretaceous and Late Miocene times (Ramos, 1998; Zamora Valcarce et al., 2006), and the Main Cordillera at the transitional area between the Southern Central and Northern Patagonian Andes. The Loncopué trough has 300 km in length in a longitudinal direction, and 40 km perpendicularly. It is bounded by two main fault systems, one located at its eastern flank formed by west-facing escarpments and the other located at its western flank formed by east-facing escarpments (Ramos, 1978; Rojas Vera et al. 2008). The easternmost fault system juxtaposes Mesozoic folded sequences corresponding to the western Agrio fold and thrust belt and Quaternary volcanic rocks accumulated at the Loncopué trough (Ramos, 1978). The westernmost fault system affects the Present arc zone, buried beneath Neogene to Quaternary volcanic products. This fault system is formed by N escarpments segmented by NE ones. Tertiary sequences are exposed at ~36ºS in the Neogene orogenic front and western slope of the Andes, where they have been dated at 27-17 Ma forming part of the Cura Mallín basin (Jordan et al., 2001; Radic et al., 2002). This reveals that the negative topographic anomaly represented by the Loncopué trough has an older origin than previously assumed. During the last years considerable amount of information related to the youngest extensional stage (Pliocene to Quaternary) at the Loncopué trough has been obtained (García Morabito and Folguera, 2005; Folguera et al. 2009), mainly related to morphological indicators such as triangular facets spatially coincident with the identified Tertiary halfgrabens. The last episode of extension in the area seems to be active based on receiver function analyses at 39ºS and gravimetric studies that show an attenuated Moho up to 30 km beneath the Loncopué trough and the Agrio fold and thrust belt (Yuan et al., 2006; Folguera et al., 2007). Bouguer anomalies show, at a broad scale, that a west dipping high angle fault juxtaposes the Agrio fold and thrust belt with the eastern Loncopué trough. Seismic lines demonstrate that this fault is extensional in origin and dips to the west controlling a wedge-like depocentre that thickens to the east. This fault is N-oriented based on surface mapping as well as magnetometric anomalies. Gravimetric residuals allow refining this geometry: Master Loncopué trough fault shows to be N-oriented at its northern half section,

while to the south it inflects to SW direction. Magnetic analyses and Bouguer anomalies reveal a rather simple geometry for the Loncopué trough as a half graben structure. Residual gravity maps and inversion gravity models highlight the great complexity that this structure internally has, corresponding to 15 to 20 km depocenters that are segmenting the long wavelength main structure alternating between the two edges of the axial trough. Depocenters at the western main fault boundary have estimated ticknesses in the order of 8 km. A series of minor depocenters developed at the axial part and easternmost sector of the trough. These series of minor structures coincide with young structure affecting Pliocene to Quaternary strata that formed rhomboedric depocenters that evolved up to probably less than 30 Ka. Seismic limes show wedge-like depocenters that correspond to Tertiary accumulations. Mechanisms that led to the formation of the Loncopué trough involve the extensional collapse of a backlimb corresponding to a basement structure. Resulting normal faults formed Late Oligocene to Quaternary depocenters that constituted the Loncopué trough. Pliocene to Quaternary sedimentation exceeded the area of Late Oligocene to Early Miocene accumulation. Particularly at the southern part of the Loncopué trough, Pliocene to Quaternary units are superimposed to a basemen high without major Paleogene accumulations. Most depocenters seem to be located over main fault strands suggesting that a transtensional origin could be linked to them.

References

Folguera A, Introcaso A, Giménez M, Ruiz F, Martinez P, Tunstall C, García Morabito E, Ramos V A (2007) Crustal attenuation in the Sourthern Andean retroarc (38º-39º30’ S) determined from tectonic and gravimetric studies: the Lonco-Luán asthenospheric anomaly. Tectonophysics 439:129- 147

Folguera A, Rojas Vera E, Bottesi G, Zamora Valcarce G, Ramos V A (2009) The Loncopué trough: a Cenozoic basin produced by the partial collapse of the southern Central Andes. Terranova In Press

García Morabito E, Folguera A (2005) El alto de Copahue – Pino Hachado y la fosa de Loncopué: un comportamiento tectónico episódico, andes neuquinos (37°-39°S). Revista de la Asociación Geológica Argentina 60: 742-761

Jordan T, Burns W, Veiga R, Pángaro F, Copeland P, Kelley S, Mpodozis C, (2001) Extension and basin formation in the Southern Andes caused by increased convergence rate: A Mid-Cenozoic trigger for the Andes. Tectonics 20: 308-324

Radic J, Rojas L, Carpinelli A, Zurita E (2002) Evolución tectónica de la Cuenca Terciaria de Cura Mallín, región cordillerana chileno-argentina (36°30´-39°S). In: 15th Congreso Geológico Argentino El Calafate Electronic Files

Ramos V A (1978) Estructura. In: Rolleri E O (ed) Geología y recursos naturales de la Provincia del Neuquén 7th Congreso Geológico Argentino (Neuquén) Relatorio Buenos Aires 9-24

Ramos, V A (1998) Estructura del sector occidental de la faja plegada y corrida del Agrio, cuenca Neuquina, Argentina. In: 10th Congreso Latinoamericano de Geología Buenos Aires 2: 105-110

Rojas Vera E, Folguera A, Zamora Valcarce G, Ramos VA (2008) The Loncopué Trough: a major orogenic collapse at the western Agrio fold and thrust belt (Andes of Neuquén, 36º40´- 38º40´S). In: 7th International Symposium on Andean Geodynamics Nize 609–612

Yuan X, Asch G, Bataillek Bock G, Bohm M, Echtler H, Kind R, Oncken O, Wólbern I (2006) Deep seimic images of the Southern Andes. In: Kay S M, Ramos VA (eds) Evolution of an Andean margin: A tectonic and magmatic view from the Andes to the Neuquén Basin (35º-39º lat) Geological Society of America Special Paper 407: 61 -72

Zamora Valcarce G. Zapata T, Del Pino D, Ansa A, (2006) Structural evolution and magmatic characteristics of the Agrio Fold-and-thrust belt. In: Kay S M, Ramos V A (eds) Evolution of an Andean margin: A tectonic and magmatic view from the Andes to the Neuquén Basin (35º-39º lat) Geological Society of America Special Paper 407: 125-145

Recent palynological studies in western Patagonia of Coyhaique region (45 º S, 72 º W), southern Chile

Rondanelli M 1, TroncosoJM 2, León C 3

1 Lab. Palinología, U. de Concepción, Los Ángeles, Chile. mrondane@udec.cl
2 Becario Fondecyt. Lab. Palinología, U. de Concepción, Los Ángeles, Chile.
3 Becaria Conicyt. Depto. Biología, U. Complutense, Madrid, España.

A palynology research is performed on the sedimentary cover of Laguna Cea and Laguna Foitzick located on the subbasin of the Simpson river in the Coyhaique region (45ºS, 72ºW), western Patagonia, in southern Chile. A landscape evolution may be observed from palynological analysis; this demonstrates the development from a woodland ecosystem covered by Coihue (*Nothofagus dombeyi* (Mirbel) Oersted) to a meadow-type ecosystem where low bush such as calafate (Berberidaceae), herbaceous layers such as different types of grass (Poaceae) and hydrophilic vegetation such as marshy plants (Cyperaceae) may be found (Rondanelli & León, 2007). The difference between the vegetation histories of both lake ecosystems seems to be the geomorphologic model that represent and its proximity to major urban centers. While the palynological record of Laguna Cea represents a change from a closed damp forest to a meadow-type, open and marshy, the pollen of Laguna Foitzick shows a continuous history of cloud forest with a greater or

lesser presence of the lake body. Vegetation structure change occurs approximately 120 years before present (BP) and coincides with the middle of the XIX Century, the first arrival of colonial settlements, clearing and animal breeding. The palynological reading supports the occurrence of fire with findings of charcoal particles on the dates of sediments analyzed for the aforementioned period which would suggest that current landscape variation in the region has been influenced by anthropic action (Rondanelli *et al.*, 2008). Pollen rain studies in both areas, Laguna Cea and Laguna Foitzick revealed that the vegetation present in both ecosystems is closely related to the degree of human intervention in each, which determine the presence of a low-diversity grassland for Laguna Cea and a forest dominated by *Nothofagus* with the presence of aquatic plants to Laguna Foitzick.

In conclusion, the history of the vegetation to the subbasin ecosystem of the Simpson river in western Patagonia of Coyhaique region, southern Chile, seemed to reveal a vegetation behavior prior to 1850 A.D. under the influence of regional climate from which that date is strongly influenced by the degree of anthropic action in this region.

This research was supported by the Chilean Science and Technology Fund- FONDECYT Nº 1050576.

References

Rondanelli M, León, C. 2007. Preliminary palynological study in the río Simpson valley, Coyhaique, southern Chile. Pollen analysis of Laguna Cea. *ARGU* Series U. Gent, Belgium (2008): 591-599.

Rondanelli M, León C, Troncoso J. M. 2008. Influencia antrópica en el paisaje reciente de la Patagonia chilena, Región de Coyhaique (45°40'S; 72°14'W) I. Registro palinológico de Laguna Cea. Rev. Polibotánica, México (*in press*).

Sedimentological and geochemical characterization of the Paleozoic carbonate rock related to a Ni-Co ore showing at the Yauli Dome – Central Peru

Rosas S 1, Muñoz C 2

1 Pontificia Universidad Católica del Perú, brosas@pucp.edu.pe
2 Explandes SRL, Peru, cmunoz@exploandes.com

A Ni-Co ore showing has been reported for the Yuraccgaga-Trapiche locality (1 km South of the San José de Andaychagua Village) at the Yauli Dome in Central Peru by different authors (Kobe 1982a, Kobe 1982b, Kobe 1984, Kobe 1990a, Kobe 1990b, Rivera and Kobe 1983, Acuña et al. 2008). These works described the rocks as a marble based on their conspicuous coarsely crystal size. The age of

these rocks is interpreted as Lower to Middle Paleozoic age by some authors (Kobe 1982a, Kobe 1982b, Kobe 1984, Kobe 1990a, Kobe 1990b, Rivera and Kobe 1983) belonging to the mainly clastic turbiditic Excelsior Group. Other authors (Acuña Soto et al. 2008) interprets the age as Pensylvanian belonging to the carbonate Copacabana Group. The latter would be the first description of this geological unit at the Yauli Dome.

Our study shows that these rocks do not display the grade of metamorphic recrystallization of a marble. The presence of coarse sized crystals is due to the characteristics of the sedimentary facies displayed in these rocks. This facies corresponds to a very coarse-grained dolomitic bioclastic grainstone or a biodolosparite. The bioclasts of this facies are mainly constitute by millimeter sized crinoidal fragments, each of them built of a unique dolomite crystal. These dolomite crystals correspond to the diagenetic recrystallization of the original Mg-calcite of the crinoids, followed by the formation of a diagenetic dolomitic cement as a syntaxial growth around the crinoidal fragments.

A geochemical analysis of a sample of these rocks indicates a relatively high content of Ni and Co (both >250 ppm), which is probably related to the Ni and Co ore formation in this locality (millerite, violarite, gersdorfite, turcekite, Kobe 1990a). Other anomalous values are Ce (134.5 ppm), Hg (>25 ppm), La (36.9 ppm), Mo (17.25 ppm), Pb (168 ppm) anf Sb (>250 ppm). This ore formation is probably of hydrothermal origin, but further studies are needed in order to establish this interpretation. There are different interpretations of its genesis in the literature cited above as well as in Bellido and Demontreuil (1972), Ponzoni et al. (1969) and others.

References

Acuña S, Cajachagua V, Soto G (2008) Ocurrencias de Ni-Co en el Domo de Yauli – Junín. Proyecto Trapiche – Yuracgaga. CD Abstracts XIII Congreso Latinoamericano de Geología / XIV Congreso Peruano de Geología. Sociedad Geológica del Perú.

Bellido E, Demontreuil L (1972) Aspectos generales de la metalogenia del Perú. Bol Ser Geol Min 1. Geol Econ 149 p

Kobe H (1982a) El ambiente de la mineralización estratoligada de Zn-Pb-Ag-Ba,-Mn, Fe-Cu en los sedimentos de la cuenca occidental Del Pucará, Perú Central. Bol Soc Geol Perú 69: 41-69

Kobe H (1982b) A stratabound Ni-Co arsenide/sulphide mineralization in the Paleozoic of the Yauli Dome, Central Peru. In: Amstutz et al. (eds.) Ore genesis – the state of the art, Berlin: Springer Verlag, 150-160

Kobe H (1984) Contribución a la metalogenia del Paleozoico del Domo de Yauli. Bol Soc Geol Perú 73: 67-91

Kobe H (1990a) Stratabound Sulfide Occurrences in the Paleozoic of the Yauli Dome, Central Peru. In: Fontboté L et al. (eds.) Stratabound ore deposits in the Andes, Berlin: Springer Verlag, 113-122

Kobe (1990b) Metallogenic evolution of the Yauli Dome , central Peru. A summary. In: Fontboté L et al. (eds.) Stratabound ore deposits in the Andes, Berlin: Springer Verlag, 267-278

Ponzoni E, Postigo A, Birbeck J (1969) Guía para el mapa letalogenético del Perú. Soc Nac Min Petrol Lima, 128 p

Rivera G, Kobe H (1983) Metalogenia del Domo de Yauli. Bol Soc Geol Perú 72: 177-193

Detrital zircons as provenance indicators in early Palaeozoic siliciclastic sandstones in NW Argentina

Rüsing T 1, Augustsson C 1, Büld M 1, Kooijman E2, Berndt J2, Zimmermann U3

1 Geologisch-Paläontologisches Institut, Corrensstrasse 24, 48149 Münster, Germany trues_01@uni-muenster.de

2 Institut für Mineralogie, Corrensstrasse 24, 48149 Münster, Germany

3 Institutt for Petroleumsteknologi, Universitetet i Stavanger, 4036 Stavanger, Norway

Age estimation and varietal studies on detrital mineral grains provide effective tools for provenance studies. It is the aim of this study to enhance the understanding of Paleozoic transportation paths in NW Argentina. We track possible crustal source areas of the influx material. This helps us to refine the palaeogeographic reconstruction of Early Paleozoic Western Gondwana. The study was conducted on zircons obtained from siliciclastic sandstones of Cambrian to Silurian age from NW Argentina (23-25°S, 65-70°W). These sediments were deposited in both tectonically active and passive margin phases along the western margin of Gondwana. So far, we have obtained data on five geological units, the Lower to Middle Cambrian Lizoite and Chalhualmayoc formations of the Mesón Group as well as the Silurian Lipeón, Salar del Rincón and Arroyo Colorado formations. The deposition of these Cambrian and Silurian sediments took place during a passive margin setting phase, in a coastal environment. Cathodoluminescence (CL) and back-scatter images were used to infer on zircon morphology. The zircons analysed are mostly oval to elongated and are varying in length between 50 and 150 µm. They are mostly slightly abraded to rounded and have, typical for a magmatic origin, oscillatory CL zoning. Most zircons contain indications of only one growth stage. Varying degrees of abrasion are implied by the heterogeneously high to low degrees of rounding. This possibly points to sediment input from both regional and local source areas. Age information on single zircon grains was obtained by in-situ U-Pb LA-ICPMS measurements. 50 to 120 zircons in each of the until now six analysed sandstones have been measured. The zircon population of the Cambrian Lizoite Formation has distinctive U-Pb age peaks at 520-580 Ma and at ca. 1080 Ma while

the younger Cambrian Chalhualmayoc Fm. has age peaks at 580 to 640 Ma, ca. 950 Ma and at ca. 2 Ga. The zircons of the Silurian Salar del Rincon Fm. have a U-Pb age peak at 620 Ma and two less pronounced peaks at around 480 Ma and 2100 Ma. The main age peaks of the Silurian Lipeón Fm. zircons are at 540-570 Ma and at ca. 2050 Ma, with another minor peak at ca.1600 Ma. The most distinctive age peaks of the Silurian Arroyo Colorado Fm are at 480-500 Ma, 580-620 and 960-1020 Ma. Less pronounced age peaks can be found at ca. 1400 Ma, ca. 1750 Ma and ca. 2.0 Ga. The prominent age peaks can be correlated with the ages of major orogenic events. 500-700 Ma ages are typical for the Pampean / Brasilian orogeny, while ages around 1 Ga are "grenvillian". 2 Ga ages can be ascribed to the Transamazonian orogeny. The absence or emergence of one or more of the pronounced age peaks can be attributed to a change in the transport path of the material, possibly due to an emerging or vanishing tectonic barrier between source area and depositional area. During the Early Cambrian, Lizoite and Chalhualmayoc fms. probably mainly received material from the Brazilian craton and the Sunsás mobile belt to the north, while the latter also received detritus from Transamazonian orogens like the Amazonian craton in the north and/or Río de la Plata craton in the southeast. The Early Silurian Lipeón and Salar del Rincón fms. both received detritus from Brazilian and Transamazonian realms, while material of Grenvillian origin is absent. The younger Silurian Arroyo Colorado Fm additionally received detritus from a Grenvillian source, probably in the north, and a Famatinian source.

The Neogene Agua de la Piedra Volcanic Complex, Patagonia, Argentina

Salani FM 1, Remesal MB 1, Parica CA 2, Cerredo ME 1

1 CONICET-Universidad Nacional de Buenos Aires. Universidad Nacional de Buenos Aires. fms@gl.fcen.uba.ar
2 Universidad Nacional de General San Martín-CONICET.

The Neogene Agua de la Piedra Volcanic Complex is a post-*plateau* eruptive assemblage located at the western border of the Oligocene basaltic *plateau* Somún Curá of the northern extrandean Patagonia. This volcanic building is composed of basal pyroclastic flows of trachytic composition and upper lava flows which span from early trachyte and lesser amounts of rhyolite to posthumous basaltic compositions (Remesal *et al.*, 2002).

The pyroclastic flows show plagioclase, arfvedsonite and aegirine crystals, lithic fragments of trachyte and pyroclastics in a glassy matrix in which bubble shards can be distinguished. The trachytic rocks occur both as lava flows and dome lava. They are porphyritic with anorthoclase, Ti biotite phenocrysts and

apatite inclusions, in a groundmass of sanidine and minor amount of anorthoclase, mica or arfvedsonite/aegirine and opaque minerals. The rhyolite facies is represented by quartz- sanidine porphyric rocks, with felsitic to microgranose groundmass of anorthoclase, mica and blue alkaline amphibole. The basaltic flows are aphyric with subophytic texture, composed by olivine plagioclase, Ti-augite and ilmenite.

The suite is characterized by its alkaline nature and displays a typical compositional gap in the mesosiliceous realm (Remesal *et al*. 2006). The inferred evolution from the basic rocks to the trachyte-rhyolite differentiates would have been controlled by the early olivine-clinopyroxene fractionation and later by plagioclase+feldspar crystallization.

The facies association and chemical evolutionary path relates this volcanic complex to other post-*plateau* assemblages of the Somún Curá environment.

References

Remesal, M B , Salani, F M, Cerredo, M E (2006) Caracterización petrológica del Complejo Volcánico Agua de La Piedra, provincia de Río Negro. 8º Congreso de Mineralogía y Metalogenia. Buenos Aires, 11-13 de octubre 2006. Acta Avances en Mineralogía, Metalogenia y Petrología: 427-434.

Remesal, M B , Salani, F M, Franchi, M R, Ardolino, A A (2002) Estratigrafía del Complejo Volcánico Agua de la Piedra, Patagonia Extrandina Norte. XV Congreso Geológico Argentino. Contribución Nº 198 en CD y en Acta 1: 61-166.

Contribution to PIP5523 and Ubacyt X185

The Marifil Formation in Northeastern Patagonia, Argentina

Salani FM 1, Chernicoff CJ 2

1 CONICET-Universidad de Buenos Aires fms@gl.fcen.uba.ar
2 CONICET- Servicio Geológico-Minero Argentino

During the Early-Middle Jurassic, a large silicic igneous province (Chon Aike Province) was emplaced in eastern Patagonia, Argentina, where it is thought to be related with the extension that led to the break-up of Gondwana (e.g. Gust *et al.*, 1985; Kay *et al.*, 1989; Pankhurst *et al.*, 1998, and references therein). This extensive volcanism largely comprises outpouring of rhyolite lavas and ignimbrites across Patagonia and Antarctica, and would have been generated by partial melting of Grenvillian-age lower crust (Pankhurst and Rapela, 1995; Pankhurst *et al.*, 1998). Volcanic and pyroclastic units have been formally referred to as the Marifil (Malvicini and Llambías, 1974; Cortés, 1981) and Chon Aike (Stipanicic and Reig,

1956) Formations in northern and southern Patagonia, respectively. A number of large calderic structures have been proposed to be associated with this eruptive activity (e.g. Aragón et al., 1996; Chernicoff and Salani, 2002; Sruoga et al. 2008).

For the present work, the Marifil Formation was sampled in the proximity of the town of Valcheta (ca. 40° 40´S – 66° 40 W), northeastern Patagonia, where it is characterized by flat lying ignimbrites interbedded with minor acidic lavas, and crosscutting thin dykes.

The ignimbrites show 15 % crystals, there being quartz (maximum size 2 mm) with conspicuous embayments, small-sized K-feldspar, twinned and zoned subhedral plagioclase, and scarse biotite. The juvenile elements are porphyritic fiammes with axiolitic devitrification and deformed glass shards in a devitrified felsitic to microgranose matrix. In some samples, the post-emplacement processes only allow to recognize shard ghosts.

Dykes represent the hypabisal facies. They are porphyritic rocks with bipiramidal quartz phenocrysts, sometimes with embayments, and minor pertite feldspar. All the crystals are bounded by spherulitic feldspar rims. The groundmass shows medium grained granular texture and is constituted by subhedral K-feldspar, muscovite and opaque minerals. Other varieties are characterized by plagioclase as dominant phenocryst fraction with subordinate quartz in a fluidal groundmass devitrified to felsitic material.

Lavas show high crystal content (>40%). The mineralogy comprises subhedral altered plagioclase as the main component; subordinate chloritized biotite with opaque exolutions and embayed quartz occur. A wide range in crystal sizes defines a seriated texture; the groundmass devitrifies to felsitic assemblage and feldspatic spherulites.

According to the major elements these rocks may be classified as subalkalic. They are mainly high silica rhyolites and subordinate dacites. Variation in some oxides (Na and K) is due to processes of devitrification and alteration which characterize these rocks. Multielement diagrams show enrichment in Th, U and K and depression in Nb, Ba, Sr and Ti. Nb (12-15, 9 ppm) and Zr (69-154 ppm) values are low, contrasting with the relatively high-Zr and Nb (>350 ppm) contents referred by Pankhurst *et al.* (1998) for volcanics of the Marifil Formation exposed in the eastern zone of the volcanic province.

REE patterns display high slope LREE, relatively flat HREE with La/Yb_{CN}= (8-14.5), and negative Eu anomaly, the latter being subtle in the dacites. In the study area, the Marifil Formation is underlain by a Triassic conglomerate (Puesto Piris Formation) and overlain by Cretaceous sandstones and conglomerates (Neuquén Group).

References

Aragón, E, Rodriguez, A M I, Benialgo, A (1996) A caldera field at the Marifil Formation, new volcanogenic interpretation, Northpatagonian Massif, Argentina. Journal of South America Earth Sciences 9 (5-6): 321–328.

Chernicoff, C J, Salani, F M (2002) Identificación de calderas asociadas a volcanitas de la Formación Chon Aike en la región del Río Seco, provincia de Santa Cruz. 15 Congreso Geológico Argentino, Proceedings. CD-ROM, Article Nº 034:6 pp.

Cortés, J M (1981) El substrato precretácico del extremo noreste de la Provincia del Chubut. Revista de la Asociación Geológica Argentina 26: 217–235

Gust, D A, Biddle, K T, Phelps, D W, Uliana, M A (1985) Associated Middle to Late Jurassic volcanism and extension in southern South America. Tectonophysics 116: 223–253.

Kay, S M, Ramos, V A , Mpodozis, C, Sruoga, P (1989) Late Paleozoic to Jurassic silicic magmatism at the Gondwana margin: analogy to the Middle Proterozoic in North America?. Geology 17: 324–328.

Malvicini, L, Llambías E J (1974) Geología y génesis del depósito de manganeso Arroyo Verde, Provincia del Chubut. 5 Congreso Geológico Argentino, Proceedings 2: 185–202. Villa Carlos Paz (Córdoba).

Pankhurst, R J, Rapela, C W (1995) Production of Jurassic rhyolite by anatexis in the lower crust of Patagonia. Earth and Planetary Science Letters 134: 23–36.

Pankhurst, R J , Leat, P T, Sruoga, P, Rapela, C W, Márquez, M., Riley, T.R. (1998) The Chon Aike province of Patagonia and related rocks in West Antarctica: A silicic large igneous province. Journal of Volcanology and Geothermal Research 81: 113-136.

Sruoga, P , Japas, S, Salani, F, Kleiman, L (2008) La Peligrosa Caldera: a piecemeal transtensional structure in the Jurassic Chon Aike silicic LIP of Southern Patagonia (47º 15´S), Argentina. Symposiun 2: Bimodal volcanism. IAVCEI 2008. General Assembly, Reykjavik. Iceland.

Stipanicic, P, Reig, A O (1956) El Complejo Porfírico de la Patagonia Extraandina y su fauna de anuros. Acta Geológica Lilloana 1: 185-297.

The basaltic volcanism of Pire Mahuida Complex, extraandean Patagonia, Argentina.

Salani FM 1, Remesal MB 1, Parica CA 2, Cerredo ME 1

1 CONICET-Universidad Nacional de Buenos Aires, Univ. Nacional de Buenos Aires. fms@gl.fcen.uba.ar

*2 CONICET-Universidad Nacional de General San Martí*n.

The Pire Mahuida Complex (PMC), located in the extraandean region of the southern part of Argentina, is a bimodal volcanic field developed during Miocene times, likely related to an extensional regime.

The PMC is made up mainly of acidic pyroclastic and lava facies, rhyolite/dacite (< trachyte) flows and lava domes. Subordinated in volume, basaltic flows overlie this extensive sequence of acidic rocks. The basic facies displays a wide span of compositional, morphological and structural features which allow distinguishing different groups. The effusion of basaltic rocks represents the final phase of the eruptive history of the PMC.

The basalts can be grouped in two main effusive stages. The first one corresponds to lava flows (~20 Ma, Ardolino *et al.* 2002) of scarce thickness (3-8m). They constitute a main NW-SE plain in the central part of the Sierra de Pire Mahuida, with some basaltic lava tongues flowing long distances northwards. Columnar jointing, colonnade and tabular structures and onion-like parting are common. Rocks are porphyritic with plagioclase phenocrysts. Groundmass consists mainly of clinopyroxene (aegirine-augite and titanoaugite), plagioclase, olivine, apatite and ilmenite. They show intersertal textures with glassy patches and rare phlogopitic mica. Xenolithic plagioclase with disequilibrium rims, clinopyroxene of xenolithic origin with exsolution of opaque minerals, orthopyroxene with clinopyroxene and opaque reaction rims were recognized. Some of basalts contain quartz crystals with glass rims and augite crowns.

The younger stage (17 Ma, Salani *et al.* 1994) of the basaltic facies is represented by the product of minor centers. At Cerro Bayo, a small volcano composed by pyroclastic and lava material, shows a volcanic sequence related to a strombolian eruption. There, brecciated agglomerate with olivine crystals, basaltic lithic and glassy matrix is followed by a basaltic flow with ultramafic inclusions (spinel lherzolithe). The lava flow is a fine grained nephelinite, with minor amounts of olivine (Fo= 85) and titanoaugite phenocrysts; the groundmass is mainly composed of olivine, clinopyroxene microlites, opaque minerals and interstitial nepheline. Vents widely distributed within the volcanic field also originated nefelinite flows that reach the southernmost part of the PMC.

The Cerro Degollado and Negro basaltic plugs are included in this later effusive stage. The characteristic mineral assemblage is mainly plagioclase, clinopyroxene, olivine, apatite and opaque minerals defining intersertal textures.

The stratigraphic position of each group matches with different chemical characteristics. The older basalts are transitional meanwhile the younger correspond to alkaline and subsaturated basalts (basanite-tephrites and nephelinites)

The PMC is the westernmost of the post-*plateau* complexes (i.e. Apas, Talagapa, Barril Niyeu, Agua de la Piedra) which partially surrounds the southern border of the mainly Oligocene Somuncurá basaltic *plateau*. Although the PMC shares some characteristics with these post-plateau complexes (i.e. chronology, typical bimodal nature), the huge volume of acidic rocks and the acid/basic ratio distinguish this complex from the remainder post-*plateau* associations.

Contribution to PIP5523 and Ubacyt X185.

References

Ardolino, A A, Salani F M, Lizuaín, A (2002) Hoja 4166-III, Gan Gan. Escala 1: 250.000, Provincia del Chubut, modificado 2005. Instituto de Geología y Recursos Minerales, Servicio Geológico Minero Argentino. Buenos Aires.

Salani, F, Linares, E, Ostera, H (1994) Edad K-Ar de las nefelinitas de la Sierra de Pire Mahuida. 7° Congreso Geológico Chileno Concepción, Chile. Actas II: 1194-1198.

Biostratigraphy and Paleobiogeography of Maastrichtian Ammonites from Quiriquina Formation, Chile

Salazar C 1, Stinnesbeck W 2, Quinzio-Sinn LA 3

1 *Inst. f. Geowissenschaften, Univ.Heidelberg, 69120 Heidelberg, Germany. csalazar@geos.uni-heidelberg.de*

2 *Departamento Ciencias de la Tierra, Universidad de Concepción, 160 C Concepción, Chile.*

The Quiriquina Formation in Central Chile is famous for its abundant and diverse ammonoid assemblage. In the type area around the bay of Concepcion in the Bío-Bío Region we identified a total of 30 species, one of the most diverse assemblages for the topmost Cretaceous. The presence of *Baculites anceps, Diplomoceras cylindraceum*, *Eubaculites carinatus, Menuites fresvillensis* and *Hoploscaphites constrictus* indicates a Maastrichtian age for the unit and correlates most of the sequence to the late Maastrichtian. The following 3 biozones are distinguished (from base to top):

Zone of *Baculites anceps*

Zone of *Eubaculites carinatus* (subdivided into the *Menuites fresvillensis* and *Kitchinites darwini* sub-biozones)

Zone without baculitids (subdivided into the *Hoploscaphites constrictus* bio zone and a zone without ammonites.

Species richness and abundance of ammonoids are high throughout the Quiriquina Formation but gradually decline in the uppermost 10 meters of the section within a unit of mottled green siltstone. No ammonites appear to be present in the last 5 meters of the unit. The assemblage shows an indopacific character but cosmopolitan, European-Tethyan and endemic faunal elements are also present.

Orogen-parallel shortening in the central Andes: examples from NW Argentina and the role of normal fault reactivation

Salazar L 1 , Kley J 1, Monaldi CR 2, Rossello EA 3

1 Institut für Geowissenschaften,Universität Jena, Germany. Luiraima.salazar@uni-jena.de
2 Universidad Nacional de Salta - CONICET, Salta, Argentina
3 CONICET - Universidad de Buenos Aires, Depto. de Ciencias Geológicas, Buenos Aires, Argentina

Multiple phases of folding indicating varying shortening directions are common in the geologic histories of many mountain belts. These variations are frequently attributed to changes in the driving forces, such as those induced by plate reorganizations. The southern central Andes have grown in an unchanged plate kinematic setting of roughly east-directed subduction over the last 40 million years. This is reflected in their overall structure which shows the dominant effect of east-west shortening. Surprisingly, though, there are also folds and thrust faults indicating shortening perpendicular to the direction of subduction. We have studied several of these transverse structures in the Tres Cruces synclinorium and Humahuaca valley of northwestern Argentina where they are particularly well exposed. A grid of balanced E-W and N-S cross-sections demonstrates that the transverse structures have accommodated much less deformation than the main longitudinal structures. Timing constraints provided by dated unconformities indicate that they formed in a relatively young (9-2 Ma) and short-lived event postdating the main longitudinal structures but followed by renewed east-west shortening. The transverse structures comprise steeply dipping reverse faults that probably originated as normal faults in the continental Salta rift of Cretaceous to Paleogene age. This is suggested by well-preserved, non-reactivated examples of east-trending synsedimentary normal faults occurring in our study area and by the observation that all major transverse structures occur within the former rift. The transverse structures thus appear to be inversion structures which involved the reverse reactivation of the inherited faults. A comparison of our own observations and of case studies from the literature on both preserved and reactivated structures in the Salta rift indicates that the reactivation of a specific normal fault is facilitated by three parameters: a strike roughly perpendicular to the shortening direction, a relatively low dip angle, and low curvature in cross-section (i.e., strongly listric faults seem harder to reactivate). The observed preference for dip-slip reactivation contradicts the

inference from sandbox analogue modelling that normal fault reactivation requires a strong strike-slip component.

The very existence of east-trending inherited faults provides no sufficient explanation for their reactivation in north-south shortening. Yet, general considerations on fault slip and stress states show that (1) in order to compensate for their steep dips, normal faults must be mechanically weak (friction coefficient m around 0.3 or less) to be reactivated in a thrust regime, and (2) when such weak faults are present, those trending parallel to the shortening direction (our transverse faults) need not be extremely weak to be reactivated as well. This holds true even for a nearly uniaxial stress state where the lesser horizontal stress is not much larger than the overburden stress. These relations suggest that just a slight increase in north-south horizontal stress may be sufficient to create the transverse structures in the former rift regions.

The recent stress field in the Precordillera of Northern Chile constrained from upper crustal microseismicity

Salazar P 1,2, Kummerow 1 J, Wigger 1 P, Moser 1 D, Asch 3 G , Shapiro 1 SA

1 *Freie Universität Berlin, FR Geophysik, Berlin, Germany, pablo@geophysik.fu-berlin.de*
2 *Departamento de Ciencias Geológicas, Universidad Católica del Norte, Antofagasta, Chile*
3 *GeoForschungsZentrum Potsdam, Potsdam, Germany*

We present a solution for the stress field in the West Fissure Fault System WFFS , Northern Chile, on the basis of an analysis of the microseismicity. The seismic activity has been recorded by a temporary local seismic network around WFFS, since November 2005. The network consists of 12 continuously recording 3-component stations, which are located at ~21°S, covering an area of c. 50 x 50 km.

Data analysis shows upper crustal microseismicity which can partly associated with the surface traces of the known branches of the WFFS. Focal depths in the north of 21°S are smaller than 20 km, whereas south of 21°S depths down to 50 km are observed. In the W-E section a distinct lower boundary of the seismicity is obvious, dipping to the West. This boundary can be related to a deep reverse structure or differences in rheological behaviour of the crust.

Among the seismic activity, two clusters were detected, one at 35-40 km depth in the SW ~110 events, between September and November 2006 with a magnitude distribution of $-0.2 \leq Ml \leq 4.2$, and another in the central part at 9-10 km depth ~120 events, between March 31, and April 28, 2006 their magnitude distribution is $0.0 \leq Ml \leq 3.5$. The central cluster exhibits characteristics of an earthquake swarm [Wigger et al., 2007].

The analysis of the stress field shows that the WFFS is subjected to transtensional regime with an extension direction of NW-SE. Dividing the area considering the geometry of the superficial structures are found two distinct signatures indicating different behaviour for each side of the WFFS. In the west it is subjected to a transpressional regime in agreement with geological observations, whereas in the east side it is subjected to a transtensional regime with a development of pull-apart basins. These tectonic behaviours of the WFFS can be related with forces associated to the thickened crust [Meijer et al., 1997] and/or forces associated to Bolivian orocline [Kley, 1999].

References

Kley J 1999 Geologic and geometric constraints on a kinematic model of the Bolivian orocline. *J. South Am. Earth Sci. 12*, 221-235.

Meijer PTh, Govers R, Wortel MJR 1997 Forces controlling the present-day state of stress in the Andes. *Earth Planet. Sc. Lett. 148*, 157-170.

Wigger P, Kummerow J, Salazar P, Asch G, Moser D 2007 Microseismicity in the West Fissure fault system, Northern Chile, *Geophysical Research Abstracts, 9*, 07136.

Large-ion lithophile elements in K-feldspar as monitors of magmatic evolution in the Velasco Pegmatitic District, La Rioja province, Argentina

Sardi F 1, Grosse P 2, Murata M 3, Navas A 4

1 Insugeo-CONICET & Universidad Nacional de Tucumán, Argentina. fgsardi@csnat.unt.edu.ar
2 CONICET & Fundación Miguel Lillo, Tucumán, Argentina
3 Naruto University of Education, Tokushima, Japan
4 Universidad Nacional de Tucumán, Argentina

The Velasco Pegmatitic District of the Pampean Pegmatitic Province (NW Argentina) is located in the central-eastern part of the Velasco range, in north-western La Rioja province. The pegmatites have three main zones: 1) marginal-external zone composed of aplite or fine-grained granite with topaz; 2) intermediate zone composed mainly of K-feldspar and accompanied by several accessory minerals such as beryl, muscovite, biotite, F-apatite, triplite and tourmaline; 3) core zone composed by quartz with subordinate beryl and/or tourmaline. The pegmatites belong to the rare element class, beryl type, and beryl-columbite-phosphate subtype. They are spatially and genetically related to Carboniferous evolved peraluminous granites.

The granites are porphyritic due to the presence of abundant K-feldspar megacrysts with very common perthite textures.

The large-ion lithophile elements Ba, Rb and Sr of K-feldspars from both pegmatites -essentially from intermediate zone- (K-$feld_{pegm}$, n = 17) and host parental granites (K-$feld_{gran}$, n = 4) were analyzed using the XRF methodology. Ba, Rb and Sr contents in K-$feld_{pegm}$ are variable, where as they are homogeneous in K-$feld_{gran}$. Overall and average contents are very different in each rock type; the average contents of Ba and Sr in K-$feld_{pegm}$ (71 ppm and 14 ppm, respectively) are significantly lower than in K-$feld_{gran}$ (465 ppm and 96 ppm), while the average Rb content in K-$feld_{pegm}$ (1214 ppm) is more than double that in K-$feld_{gran}$ (522 ppm). In general, the Ba, Rb and Sr contents in K-$feld_{pegm}$ are in agreement with other districts and fields from the Pampean Pegmatitic Province and world-wide. The K-$feld_{pegm}$ shows Rb enrichment and Ba and Sr depletion relative to parental K-$feld_{gran}$. Since granitic pegmatites usually represent the late to post-magmatic stages of a continuous fractionation trend, large-ion elements such as Ba, Rb and Sr are excellent guides capable of explaining the magmatic evolution in the Velasco district, which is not evident using major element. So, it can affirmed that the Carboniferous magmatism developed in the center-eastern region of the Velasco range has produced several Be-mineralized and extremely fractionated pegmatites.

Mid Ocean Ridge Basalts from the Pacific Rivera Plate, Mexico: Heterogeneous geochemistry and geochronology

Schaaf P 1, Bandy W 1, Mortera C, Michaud F 2, Ruffet G 3

1 Instituto de Geofisica, UNAM, 04510 México, D.F. pschaaf@geofisica.unam.mx
2 UMR, Géosciences Azur, UPMC, La Darse, 06230 Villefranche sur Mer, France
3 CNRS, UMR, Géosciences Rennes, 35042 Rennes, France

Knowledge of the age and chemical and isotopic composition of seafloor basalts is crucial for petrogenetic modeling of continental arc magmas. However, for Mexico few information is available, which was primarily that obtained from the DSDP perforations front of Acapulco and in the mouth of the Gulf of California. In this contribution we present new geochemical and geochronological analyses of Mid Ocean Ridge Basalts, partly collected by a submersible close to the Middle America Trench (MAT; samples NM) and others dredged at depths between 3590 and 4060 m north of the Rivera Transform Fault (samples BMP) in the vicinity of the East Pacific Rise. The sampled area lies at the southeastern edge of the Rivera Plate close to its poorly defined boundary with the Cocos Plate and the trench. Hand sized pillow fragments are glass-free and characterized by a fresh interior zone with porphyritic texture and a slightly more altered outer rim. Two generations of olivine phenocrysts were observed. Large grains without chrome spinel and smaller grains with chrome spinel and other inclusions. Both occur together with micro-

phenocrysts of uninverted (monoclinic) pidgeonite and plagioclase (An_{60}-An_{80}) in the fresh interior zone whereas the outer rim zone shows more alterated olivines, smectite, and secondary carbonates in vesicles. SiO_2 contents are between 48.6 and 52.2 wt.%. TiO_2 is substantially elevated in BMB samples (2.5 to 3.9 wt.%) and between 1.4 to 1.6 wt.% in NM samples. MgO is heterogeneous in BMB samples (3.2 to 6.2 wt.%) and more homogeneous at higher levels (6.4 to 7.3 wt.%) in the area close to the trench (NM samples). $^{87}Sr/^{86}Sr$ and □ Nd values are quite homogeneous in BMB samples with N-MORB-like ratios of 0.7025 and +11.8, respectively. NM samples show more enriched □ Nd from +8 to +10. Pb isotopic ratios, on the other hand, are somewhat lower than typical Pacific MORB values but lie well in the depleted mantle field. Within error, consistently young $^{39}Ar/^{40}Ar$ ages of 1.3 ± 0.3 Ma and 1.4 ± 0.7 Ma were obtained from the interior zone and the outer rim of BMB samples whereas NM samples were dated between 2.8 and 3.0 Ma and ca. 12 Ma closest to the MAT.

BMB samples represent young high-Ti basalts and are possibly related to a propagating rift of the current East Pacific Rise. The ages between 2.8 and 3 Ma for one NM sample set approximately confirm the boundary between young and old oceanic crust. The formation of these basalts can be interpreted as a continuation of the Moctezuma Trough. On the other hand, the age of the NM samples closest to the trench (ca. 12 Ma) is consistent with the old seafloor south of the El Gordo graben indicating a lack of organized seafloor spreading within the graben. Obviously, the oceanic crust along the MAT in the studied segment is composed of old as well as young components which most likely complicated the tectonic processes acting at this margin.

First results from the ICDP deep drilling PASADO* project of maar Laguna Potrok Aike (Santa Cruz, Argentina

Schäbitz F and the PASADO-team

Seminar for Geography and Education, University of Cologne, Gronewaldstr. 2, 50931 Cologne, Germany

First results (core catcher sample analysis and scanning data) from sediment cores originating out of the 100 m deep maar lake Laguna Potrok Aike (52°S, 70°W) situated in the south-eastern Patagonian steppe more than 80 km away from the Andean forest will be presented providing information about the vegetation and climate history during the Late Quaternary. Results were achieved from the PASADO*-ICDP deep drilling initiative, which took place from September to November 2008 at Laguna Potrok Aike. During this drilling campaign lake sediments up to a depth of about 100 m were cored. The core catcher samples were collected each 3 m. The pollen proxy indicates variability in vegetation history mainly triggered by moisture availability and temperature.

**Potrok Aike Sediment Archive Drilling Project*

The paleoclimatic significance of chemical, isotopic and detrital proxies in different high-resolution stalagmite records from the superhumid southernmost Chilean Andes (53°S)

Schimpf D 1, Kilian R 1, Mangini 2, Kronz A 3, Spötl C 4

1 Geology Department, FB VI, University of Trier, Behringstr. 16, 54286 Trier, Germany schimpf@uni-trier.de

2 Heidelberg Academy of Sciences, c/o Institute for Environmental Physics, INF 229, 69120 Heidelberg, Germany

3 GZG, University of Göttingen, Goldschmidtstr. 1, 37077 Göttingen, Germany

4 Univ. of Innsbruck, Inst. f. Geology and Palaeontology, Innrain 52, 6020 Innsbruck, Austria

Stalagmites play an important role in analysing paleoclimate due to a good age control by U/Th dating and the possibility of up to sub-annual resolution of their isotope and geochemical signals (*Henderson, 2006).* For the first time, chemical and isotopic signatures of stalagmites from the superhumid Andes in southernmost Chile (53°S) are presented. The samples MA1, MA2 and MA3 grew continuously during the last 4-6 kyrs in the small Marcelo Arévalo (MA) cave at the Pacific coast, which was formed by coastal erosion. The cave's host rocks consist of schists and granodiorites, what enables a wide range of chemical and detrital components, which were accumulated successively on top of the stalagmites. Minerogenic detritus from the host rocks (monitored by insoluble elements like Y and HREE) can only be deposited on each stalagmite by exceeding a certain precipitation depending drip rate threshold value. Therefore, we consider the Y content in the stalagmites as being influenced exclusively by precipitation. Hydrochemical proxies (e.g. Mg, U, Sr contents and Mg/Ca ratios measured with up to sub-annual resolution) are transported as cations in the drip water to the top of the stalagmite, where they are incorporated in the calcite. Their concentration in the stalagmite is controlled by the concentration in the drip water and depends on (i) dilution and (ii) the degree of acidification of the generally acid peaty soil water in the catchment. The latter depends also on precipitation as well as on the water level in the soils and is modified by acidification and buffering processes related to occasional deposition of tephra layers in this area. A millennium-scale increase in the precipitated hydrochemical elements was caused by a soil acidification after the deposition of a tephra layer from the adacitic Mt. Burney volcano. The acidification was caused by alteration of sulphur-bearing glassy pumices in cave-overlying peaty soils after the 4.3 kyrs B.P. eruption. However, this long-term acidification trend is also strongly modified by the regional precipitation. Therefore, the hydrochemical and detrital records show very similar

ranges and variations in the three stalagmites, confirming their importance as precipitation proxies.

High correlation of $\delta^{13}C$ and $\delta^{18}O$ values of each stalagmite suggest a predominant non-linear evaporation controlled kinetically effect (especially drip rate dependent) on the isotopic fractionation, which is slightly superimposed by a temperature controlled fractionation. Unfortunately, the isotopic fractionation of the three stalagmites shows a bad correlation. Only C and O isotopes of stalagmite MA1, which suffered the highest drip rates (Mühlinghaus et al., 2008), show a relatively good correlation with the abovementioned chemical proxies. Due to these non-linear effects, we can interpret only the MA1's isotope record as being influenced mainly by precipitation. The isotopic record of the stalagmites MA2 and MA3 is especially controlled by frequent changes in the pathways of water in the roof of the cave, which resulted in distinct and individual amount of evaporation, which was not related to general temperature or humidity changes in the cave. Our record show that Neoglacial cold phases as between 2.5 and 3.5 kyrs B.P. and the little Ice Age are characterised by relatively low precipitations, while the period between 1.5 and 2.0 kyrs B.P. and especially the Medieval Warm Period was extremely humid.

Another focus lies on the reconstruction of the behaviour of the southern hemispheric westerly (SHW) wind zone (about 35°S to 60°S). The cave is situated in the southern part of this Westerly zone and is sensitive for its intensity variations and/or north-south shifts. The drip rate and precipitation proxies suggest a weakening of the SHWs during cold periods and vive versa during the Neoglacial.

Comparison with El Niño Southern Oscillation (ENSO) influenced paleoclimatic archives (lacustrine and marine sediment cores from Ecuador and Peru: Moy et al., 2002, Rein et al., 2005) show correlations: Strong ENSO events are accompanied with less precipitation at the MA cave and vice versa. The comparison with a salinity record of another marine sediment core at 41°S (Lamy et al., 2004), which is influenced by the westerly intensities, shows good correlation. In addition, we have found an influence of the sun's DeVries cycle in the Y and Mg/Ca records of stalagmite MA1.

References

Henderson G M (2006), Caving in to New Chronologies. Science 313 620-622

Mühlinghaus C, Scholz D, Mangini A (2008) Temperature and precipitation records from stalagmites grown under disequilibrium conditions: A first approach. PAGES News 16 No3

Moy CM, Seltzer GO, Rodbell DT, Anderson DM (2002) Variability of El Niño/Southern Oscillation activity at millennial timescales during the Holocene epoch. Nature 420 162-165

Rein B, Lückge A, Sirocko F (2005) El Niño variability off Peru during the last 20,000 years. Paleoceanography 20 PA4003 doi:10.1029/2004PA001099

Lamy F, Kaiser J, Ninnemann U, Hebbeln D, Arz H, Stoner J (2004) Antarctic timing of surface water changes off Chile and Patagonian ice sheet response. Science 304 1959-1962

Altiplano peatlands in NW Argentina as archives for palaeoclimate research – potential, challenges and limitations

Schittek K 1, Flores F 2, Torres G 2, Lupo L 2,3

1 Seminar für Geographie und ihre Didaktik, Universität Köln, Germany, kschittek@web.de
2 Laboratorio de Palinología, Universidad Nacional de Jujuy, Argentina
3 CONICET, Argentina

High-Andean cushion peatlands are among the most unique and characteristic ecosystems of the Andes. They are situated on steep slopes below wells or in wet brooks and valley bottoms at 4000 to 4800 masl. The primary cushion-forming and peat-producing plant species of these soligenous peatlands in NW Argentina are among the Juncaceae and Cyperaceae. As they have the quality to be very sensitive towards environmental changes, they are well-suited for palaeoecological studies. These high-altitude peatlands can develop astonishing accumulation rates, depending on topography and a permanent and balanced water input. Correct site selection and investigation of drainage areas are fundamental for the understanding and interpretation of the peat cores. Once having dried out, caused by dry climate phases and/or erosion, the plant cover dies rapidly and the peat oxidizes.

Results of multi-proxy studies of several peat cores from high-altitude cushion peatlands of the Eastern Cordillera of the NW Argentine Andes (Jujuy and Salta provinces) are presented. AMS ^{14}C dates provide continous chronologies for the last 2000 years with one site covering 10000 years. During the mid-Holocene dry phase (8,5 to 2 ka BP) peat accumulation was significantly reduced or not existent.

Biological (plant macrofossils and fossil charcoal particles) and geochemical (TC, TN, humification) analysis, so far, were used to detect palaeoenvironmental changes. The investigation of plant macrofossils represents one of the first advances concerning Andean peatlands. The abundant presence of charred gramineae particles (only before 900 BP) is surprising and gives evidence of a vegetation change, possibly supported by a change towards a more shrub-dominated highland steppe as a result of intensified pasturing activities by the growing Andean human population. The dominating control on fire before 900 BP appears to be climate.

Belemnites in shallow water carbonates of the Sierra de La Silla (Lower Cretaceous, Nuevo León, NE Mexico)

Seibertz E 1, Spaeth C 2

1 IUG, Technische Universität Braunschweig, Germany e.seibertz@web.de
2 GPI, Universität Hamburg, Germany chspaeth@web.de

The belemnite bearing locality Sierra de La Silla is situated in northeastern Mexico in the northern part of Nuevo León between Monterrey in the north and Montemorelos in the south. The Sierra is a narrow anticline separated from the eastern frontrange of the Sierra Madre Oriental in the west by a wide valley of some ten kilometers. The steeply inclined flanks of the range generally consist of Lower Cretaceous carbonates with a narrow stripe of Jurassic clastics in the center of the Sierra and Upper Cretaceous carbonates in its outer slopes. Some twenty km south of Monterrey the village of El Alamo is situated with an abandoned quarry nearby. In this section on the western flank of the Sierra, the following regional lithostratigraphic units are exposed (comp. SEIBERTZ & SPAETH, 2005: fig. 2): the upper part of the Tamaulipas Superior Formation (KiTS, Aptian to Middle Albian), the Cuesta del Cura Fm. (KiCC, Middle Albian to Cenomanian), the Agua Nueva Fm. (KiAN, Cenomanian / Turonian), and a greater part of the San Felipe Fm. (KiSF, Turonian to lowermost Coniacian).

The top of the KiTS is characterized by thick-bedded dolomitic limestones, the beds being separated from each other by stylolithic joints. The base of the overlying KiCC consists of a bundle of several erosion surfaces followed by flaser-bedded and undulated light and dark grey limestone. It is sparitic in the lower part of the formation where erosion and omission surfaces / hardgrounds dominate, and micritic and darker in the upper part where flaser-bedding and undulation are less developed. Light grey chert occurs in nodules or stratiform bands of *Thalassinoides* shape.

The KiTS is assumed to be deposited in an open and deeper sea, whereas the KiCC was accumulated in a shallow water environment at this location. In contradiction to the opinion of some authors to represent entirely deep-water conditions, the KiCC shows here special depositional environments in accordance with its paleogeographic position (SEIBERTZ, 1998). Thus, a coincidence with inundated Jurassic land masses is obvious, the structures of which are strongly basement controlled (WILSON, 1990). Biostratigraphic assignment of the upper KiTS is made by the occurrence of *Neohibolites* ex gr. *minimus* and mesohibolitids giving a basal Mid-Albian age. The lower part of the KiCC is biostratigraphically fixed by belemnites, too, among which several species and subspecies of the genus *Neohibolites* are diagnostic for Middle and Upper Albian, and which are often accumulated in condensation, and arranged by currents. The same age is given by ammonites of the genera *Mortoniceras, Worthoceras, Anisoceras,* and *Mariella.* Other faunal content comprises brachiopods (*Sellithyris*, *Rectithyris,* and *Terebratulina* s.l.),

prises brachiopods (*Sellithyris*, *Rectithyris,* and *Terebratulina* s.l.), echinoids (*Holaster,* and *Hemiaster*), inoceramids, and microcrinoids of *Roveacrinus* affinity.

The Mid-Albian part of the KiCC is characterized by *Neohibolites* ex gr. *minimus* (MILLER), occurring in different formtypes, together with *N. minimus clavaformis* SEIBERTZ & BUITRON, here represented by larger and thicker rostra than at its type locality Tepexi de Rodríguez in the State of Puebla (SEIBERTZ & BUITRON, 1987). In the basal beds of the KiCC two forms are cooccurring with several specimens strongly resembling the Upper Albian *N. praeultimus* SPAETH, and the Lower Cenomanian *N. ultimus* (D'ORBIGNY) respectively, both being looked upon as new subspecies of *N. minimus* showing an iterative radiation. Besides these neohibolitids two species of *Mesohibolites* are cooccurring, *M. semicanaliculatus* (BLAINVILLE), and *M. spicatus* (SWINNERTON) respectively. Originally described by SWINNERTON (1936-55) under reservation as *Neohibolites*, the mexican specimens confirm the doubts and lead to a generic change (SEIBERTZ & SPAETH, 2002, 2005). The lower Upper Albian part of the KiCC is characterized by *Neohibolites oxycaudatus* SPAETH together with the last occurrences of the *N. minimus* group. The higher Upper Albian part of the KiCC can be determined by the real *N. praeultimus* SPAETH.

References

Seibertz E (1998) Evolution of the Mid-Cretaceous in northern Mexico under paleoceanographic aspects. Rev mex Cien geol 15,1: 87-90

Seibertz E, Buitron B E (1987) Paleontología y estratigrafía de los *Neohibolites* del Albiano de Tepexi de Rodríguez, Edo. de Puebla (Cretácico Medio, México). Rev Soc mex Paleont 1,1: 285-299

Seibertz E, Spaeth C (2002) Cretaceous belemnites of Mexico III. The Albian *Neo-* and *Mesohibolites* of the "Mexican Solnhofen" Tepexi de Rodríguez (State of Puebla) and their biostratonomy (Lower Cretaceous). N Jb Geol Paläont Abh 225,1: 55-74

Seibertz E, Spaeth C (2005) Cretaceous belemnites of Mexico IV. Mexican *Mesohibolites* and paleobiogeographical implications on the distribution of the genus (Albian, Lower Cretaceous). N Jb Geol Paläont Abh 231: 95-113

Swinnerton H H (1936-1955) A monograph of British Lower Cretaceous belemnites. Palaeont Soc pt 1: 1936 part 2: 1937 part 3: 1948 part 4: 1952 part 5: 1955: 86 p

Wilson J L (1990) Basement structural controls on Mesocoic carbonate facies in norteastern Mexico – A review. Actas Fac Cien Tierra UANL Linares 4: 5-45

The birth of the Andes: Abrupt onset of rapid arc growth ~91 Ma ago

Sempere T 1,2, Demouy S 1, Benoit M 3,4, García F 5, Jacay J 6, Rousse S 1,2, Saint-Blanquat M de 1,4

1 Univ. de Toulouse; UPS (OMP); LMTG; 14 avenue Edouard Belin, F-31400 Toulouse, France, sempere@lmtg.obs-mip.fr
2 IRD; LMTG; F-31400 Toulouse, France
3 Univ. de Toulouse; UPS (OMP); DTP; 14 avenue Edouard Belin, 31400 Toulouse, France
4 CNRS; LMTG; F-31400 Toulouse, France
5 Facultad de Geología, Geofísica y Minas, Univ. Nacional de San Agustín, Arequipa, Peru
6 Escuela de Ingeniería Geológica, Universidad Nacional Mayor de San Marcos, Lima, Peru

The Central Andean margin underwent a profound change at ~91 Ma. Since the Late Paleozoic, the margin had dominantly undergone tectonic stretching, which had led to the development of an overall marine backarc basin deepening to the southwest. In contrast, the Late Cretaceous – Paleocene magmatic arc (the Toquepala arc) was large enough to form a significant, continuous relief feeding a backarc basin gently sloping to the northeast and occupied by mostly continental environments. This emergence of a proto-Andean relief reflected incipient crustal thickening along the arc and was associated with a massive reactivation of volcanism but no detectable sign of tectonic shortening.

The initiation of the construction of the Toquepala arc was rapid, as reflected by the abrupt invasion of the backarc basin by coarse volcaniclastic conglomerates (in the SW) and mostly continental environments. A ≥700 m-thick succession of continental, coarse- to (reddish) fine-grained deposits sharply overlies the Albian-Turonian carbonate succession that had slowly accumulated in the backarc until then (Sempere et al., 2002). Whereas the latter is nearly devoid of volcanic intercalations or detritus, the former includes volcaniclastic deposits as well as tuffs and lava flows (Callot et al., 2008). This sharp turning point in the stratigraphic record is dated at ~91-90 Ma (Callot et al., 2008) and coincides with the only significant uplift known in coastal southern Peru (Wipf, 2006), and with the emplacement, between 91 and 70 Ma, of the most voluminous units in the Coastal Batholith (Mukasa, 1986).

Coeval volcanic rocks, that were mainly erupted subaerially, and subordinate volcaniclastic and fine-grained clastic deposits, make up the ≥1.5 km-thick Toquepala Group, which is known only south of 16°40'S. North of this latitude the Toquepala arc is represented by most plutons in the Coastal Batholith. Coeval erosional products of this arc (Matalaque Formation) crop out to the northeast, where their thickness may be >1.5 km. Large ignimbrite sheets were erupted between ~75 and ~65 Ma (Martínez and Cervantes, 2003). Activity of the Toquepala arc apparently waned after ~50 Ma, and the youngest available ages are slightly older than ~45 Ma (Clark et al., 1990).

The Coastal Batholith forms a giant, >5 km-thick tabular body emplaced into strata of Middle Jurassic age consisting of dark shales and subordinate fine sandstones. Below the batholith, these rocks were metamorphosed to amphibolites and quartzo-feldpathic metarenites, and mainly deformed ductilely. The batholith is composed of interpenetrating smaller tabular units, that are generally ~100-500 m-thick each and display petrological gradations from mafic (dioritic to gabbroic), finer-grained facies near their bottom to felsic (granitic), coarser-grained facies near their top. Available geochronologic data indicate that the Coastal Batholith was built by discrete plutonic pulses in the Early Jurassic, Late Jurassic, mid-Cretaceous, and most of all Late Cretaceous-Paleocene, albeit with significant regional variations along strike (Mukasa, 1986; Clark et al., 1990). In particular, a significant pulse of pluton emplacement occurred at ~62-61 Ma along a >300 km-long segment of the arc (Mukasa, 1986; Quang et al., 2003). This pulse and the major reactivation of volcanism at ~91 Ma coincided with major increases in accumulation rate in the backarc basin (Sempere et al., 1997; Callot et al., 2008), strongly suggesting that magmatic growth of the arc caused an orogenic development that was large enough to increase subsidence in the backarc, and thus to regionally flexure the lithosphere.

The rapid arc growth initiated at ~91 Ma in southern Peru was thus responsible for building a continuous proto-Andean cordillera, whose origin was magmatic, not tectonic. This accelerated arc growth must have been caused by a profound modification in the conditions of subduction. Although plate motions and velocities cannot be directly estimated for times within the long mid-Cretaceous normal superchron (~124.5-83.5 Ma), we observe that significant developments occurred in the East Pacific at about the same time. In particular, the Caribbean-Colombian (CCOP) and Gorgona (GOP) oceanic plateaux were rapidly constructed 91.4 ± 0.4 and 88.9 ± 1.2 Ma ago, respectively (Kerr and Tarney, 2005), both implying a significant mantle thermal anomaly: large amounts of basalts had to be extracted from the mantle to build the extensive CCOP, and generation in the GOP of the only Phanerozoic komatiites known on Earth required anomalously hot mantle temperatures. Remarkably, both phenomena are compatible with the entire Pacific oceanic lithosphere having been reheated between approximately ~100 and, more precisely, 70 Ma (Ritzwoller et al., 2004). The conjunction of these quite anomalous thermal phenomena reflect a deep modification of the Pacific mantle convection and thus of subduction conditions along its margins. It is particularly striking that anomalous heating of the East Pacific lithosphere between ~91 and 70 Ma, as we infer here from independent sources, exactly coincided with emplacement of large plutonic volumes between 91 and 70 Ma in Peru (Mukasa, 1986).

References

Callot P, Sempere T, Odonne F, Robert E (2008) Giant submarine collapse of a carbonate platform at the Turonian-Coniacian transition: The Ayabacas Formation, southern Peru. Basin Research 20: 333-357

Clark AH, Farrar E, Kontak DJ, Langridge RJ, Arenas MJ, France LJ, McBride SL, Woodman PL, Wasteneys HA, Sandeman HA, Archibald DA (1990) Geologic and geochronologic constraints on the metallogenic evolution of the Andes of southeastern Peru. Economic Geology 85: 1520-1583

Kerr AC, Tarney J (2005) Tectonic evolution of the Caribbean and northwestern South America: The case for accretion of two Late Cretaceous oceanic plateaus. Geology 33: 269-272

Martínez W, Cervantes J (2003) Rocas ígneas en el sur del Perú: Nuevos datos geocronométricos, geoquímicos y estructurales entre los paralelos 16° y 18°30'S. Boletínes INGEMMET (D) 26: 1-140

Mukasa SB (1986) Zircon U-Pb ages of super-units in the Coastal batholith, Peru: Implications for magmatic and tectonic processes. Geological Society of America Bulletin 97: 241-254

Quang CX, Clark AH, Lee JKW, Guillén J (2003) ^{40}Ar-^{39}Ar ages of hypogene and supergene mineralization in the Cerro Verde-Santa Rosa porphyry Cu-Mo cluster, Arequipa, Peru. Economic Geology 98: 1683-1696

Ritzwoller MH, Shapiro NM, Zhong SJ (2004) Cooling history of the Pacific lithosphere. Earth and Planetary Science Letters 226: 69-84

Sempere T, Butler RF, Richards DR, Marshall LG, Sharp W, Swisher III CC (1997) Stratigraphy and chronology of Late Cretaceous - Early Paleogene strata in Bolivia and northwest Argentina. Geological Society of America Bulletin 109: 709-727

Sempere T, Carlier G, Soler P, Fornari M, Carlotto V, Jacay J, Arispe O, Néraudeau D, Cárdenas J, Rosas S, Jiménez N (2002) Late Permian-Middle Jurassic lithospheric thinning in Peru and Bolivia, and its bearing on Andean-age tectonics. Tectonophysics 345: 153-181

Wipf M (2006) Evolution of the Western Cordillera and coastal margin of Peru: Evidence from low-temperature thermochronology and geomorphology. ETH Zurich PhD n°16383

Block rotations and its tectonic implications in the Isthmus of Panama: new paleomagnetic data of several structural domains in Panama, Central America

Silva C 1, Bayona G 1,Channell JET 2

1 Corporación Geológica ARES, Colombia; Smithsonian Tropical Research Institute, Panama, casilvac@bt.unal.edu.co

2 UF, University of Florida, USA

In order to determine preliminary block rotations and paleolatitudinal movements of the Panama volcanic arc, Late Cretaceous to Pleistocene tuffs, lavas and calcareous sandstones, were sampled in a total of 23 sites of five areas of Panama.

In the Colon area, the left-lateral Río Gatún fault places Upper Cretaceous and Miocene (?) rocks to the north and Eocene-Oligocene strata to the south. Mean directions of two sites in the northern block, after tilt correction, are westerly (Paleocene, *D* 275.4, *I* -20.8, *k* 20.46, $\alpha 95$ 10.9; Miocene (?), *D* 264.6, *I* 5.3, *k* 292.35, $\alpha 95$ 3.5), whereas the mean direction of a site in the southern block is pointing northward (Oligocene, *D* 346.3, *I* 14.3, *k* 18.43, $\alpha 95$ 14.4). Comparison between Oligocene and Miocene directions documents a counterclockwise rotation of the northern block of the Río Gatún fault (81.7º ± 13.3º) with respect to the southern block. Cenozoic sites record the northward path of the trailing edge of the Caribbean plate, from 10.8ºS for Paleocene to 6.6ºN for Oligocene; however more sites need to be collect in order to better constraint this northward translation. Components isolated in the El Valle volcano and Canal areas for Middle Miocene to Pleistocene rocks, indicate normal and reverse directions similar to the present direction of the magnetic field, therefore indicating no major latitudinal displacement of the Panama Isthmus during Neogene.

Northward migration of the Panama arc is consistent with the Pacific origin of the Caribbean plate and counter-clockwise vertical axis rotation of several blocks in Panama could be related with the South American Plate collision since Pliocene.

Comprehensive Geohazard Assessment for Honduras and the Development of a National GIS on Georisks

Silva E 1, Strauch Ws 2., Castellon A 3, FunesG 4

Honduras was affected heavily by Hurrican Mitch in 1998. Thousands of people died due to landslides and inundations. In the aftermaths of the disaster many projects were carried out to detail the natural hazards of the country. In Honduras, there exists, unfortunately, no centralized geosciences institution. The resulting data of the many projects were archived rather disperse in many institutions, universities, NGO´s or by individual researchers. Access to these data for further works was frequently difficult. Data sharing was not always accomplished in an optimal way between the different scientists and institutions. Sometimes, important data were not available rapidly in case of an emergency. There was also an imminent danger of data loss as data archiving was not always assured in a proper way.

COPECO, the Honduran Emergency commission, tried to establish a GIS system in their headquarters and BGR and the cooperating geosciences institutions in the neighboring countries were trying to support this development. Data from many sources were collected and an inventory was elaborated, but, due to the lack of scientific personnel at COPECO, the progress in the establishment of a GIS and the use of the data remained slow. Lately, COPECO succeeded to obtain the

supervision of a development program on the Mitigation of Natural Disasters (PMDN). This program is funded by World Bank which works already since 2001 in the country to improve the capacity of the municipalities on disaster prevention and the reduction of their vulnerability. The project has elaborated hazard and vulnerability maps for the more than 60 most vulnerable municipalities in Honduras. The results are organized in a GIS based on ESRI software (ArcGIS).

It is envisioned that the technical personnel working in this program can now help to provide the critical mass to establish a permanent Unit for a GIS on Georisks at COPECO. First steps were gon to create a National GIS for Georisks which can also cooperate efficiently with national institutions as University of Honduras and with BGR and the geosciences institutions in the other Central American countries.

References

Harp, E. L.; Hagaman, K. W.; Held, M. D.; McKenna, J. P. (2002) Digital inventory of landslides and related deposits in Honduras triggered by hurricane Mitch, United States Geological Survey (USGS) , United States Agency for International Development (USAID), 2002, 18 p.

Mastin, M. C. (2002) Flood-hazard mapping in Honduras in response to Hurricane Mitch, United States Geological Survey (USGS), 2002, 45 p

Telford, J.; Arnold, M.; Harth, A. (2004) Learning lessons from disaster recovery: the case of Honduras, The World Bank (WB), 2004, 81 p.

Sr-Nd-Pb isotopic compositions of Iztaccíhuatl and Tláloc-Telapón volcanoes, Sierra Nevada, Mexico: Evidence for different magma generation processes

Solís Pichardo G 1, Martínez-Serrano R 2, García-Tovar G 2, Cadoux A 2

1 Departamento de Geoquímica, Instituto de Geología, Universidad Nacional Autónoma de México, México, D.F. 04510 (gsolis@geofisica.unam.mx)

2 Instituto de Geofísica, Universidad Nacional Autónoma de México, México, D.F. 04510

The Sierra Nevada volcanic range is located in the east-central part of the Trans-Mexican Volcanic Belt (TMVB). It is composed from north to south by three volcanic complexes: Tláloc-Telapón (TTVC), Iztaccíhuatl (IVC) and Popocatépetl. The Sierra Nevada displays an almost perpendicular position with respect to the east-west orientation of the Neogene TMVB, which is associated to the subduction of the Rivera and Cocos oceanic plates underneath the North America Plate. Geological studies have shown that magmatic activity in the Sierra Nevada initiated during the Pliocene at its northern end (TTVC) and later migrated southwards

towards Popocatépetl volcano which current eruptive cycle began at 23 ka. However, recent K-Ar and ^{14}C age determinations of lavas and pyroclastic deposits from the northwest end of the Sierra Nevada (TTVC) indicate ages younger than 32 ka, suggesting that the proposed magmatic migration is not clearly displayed.

Iztaccíhuatl volcanic products with ages from ~1.7 Ma to 12 ka are represented by calc-alkaline andesitic-dacitic lava flows, minor occurrence of basaltic andesite, domes, pyroclastic deposits and some scoria cones. Trace element patterns show enrichments of LILE with respect to HSFE. Together with negative anomalies of Nb, Ta, P, and Ti, and positive anomalies of Ba, Rb and Pb for the majority of the rocks, this suggests a depleted magma source in the subcontinental lithosphere modified by subduction fluids and some influence of slab components. The isotopic results for the IVC products show the following ranges: $^{87}Sr/^{86}Sr$ from 0.70381 to 0.70538, εNd from –0.35 to +4.08, $^{206}Pb/^{204}Pb$ from 18.60 to 18.77, $^{207}Pb/^{204}Pb$ from 15.55 to 15.63 and $^{208}Pb/^{204}Pb$ from 38.28 to 38.63, suggesting different degrees of interaction with the continental crust.

The Tláloc-Telapón VC products are composed of calc-alkaline early andesitic – late rhyolitic lava flows, important pyroclastic deposits and minor domes. The trace element patterns also suggest a depleted source in the subcontinental lithosphere with an important influence of slab components. The isotopic results for the TTVC vary as follows: $^{87}Sr/^{86}Sr$ = 0.70441 - 0.70519, εNd = –0.51 - +1.64, $^{206}Pb/^{204}Pb$ = 18.62 - 18.76, $^{207}Pb/^{204}Pb$ = 15.55 - 15.67 and $^{208}Pb/^{204}Pb$ = 38.32 - 38.85. In general, rocks from this complex display stronger evidence for magma interaction with the continental crust in comparison to other central TMVB volcanoes such as Iztaccíhuatl, Popocatépetl and Nevado de Toluca.

U-Pb LA-ICP-MS age determinations of growth impulses in zircons from Carboniferous post-orogenic granites, Sierra de Velasco (NW-Argentina)

Söllner F 1, Grosse P 2, Gerdes A 3, Toselli AJ 4, Rossi JN 4

1 Dept. of Earth and Environmental Science, Geology, LMU München, Germany
2 CONICET & Fundación Miguel Lillo, Tucumán, Argentina
3 Dept. of Earth Sciences/Geography, Mineralogy, Goethe University Frankfurt, Germany
4 CONICET & Universidad Nacional de Tucumán, Argentina

The central and eastern part of the Sierra de Velasco (Sierras Pampeanas) is formed by the large Huaco (*HG*) and Sanagasta (*SG*) syeno- to monzogranite massifs, the small zinnwaldite and fluorite bearing La Chinchilla monzogranitic stock (LCS), and unnamed tourmaline bearing equigranular monzogranite bodies (*eqG*). The two voluminous granites intrude Famatinian metagranites (Ordovician) and crosscut De-

vonian mylonitic shear zones (Höckenreiner et al. 2003). The *LCS* sharply intrudes into the *HG*, whereas the *eqG* are inner and boarder facies of the *HG*.

Cathodoluminescence (CL) investigations of the zircons from all granites reveal a multi-phase crystallization history. The inner most part of the zircons is formed by inherited cores (except in the Sanagaste granite). These cores are subrounded to globular and consist of magmatic growth structures. The lack of angular fragments and a homogeneous age distribution imply that the zircon cores were formed by dissolution processes following Ordovician magmatic events.

Ages of inherited zircon cores represent two phases of crystallization at 476 ± 5 Ma and 454 ± 4 Ma (2σ). This two-phase age distribution is identical to that found in monazites from surrounding Famatinian metagranites (De los Hoyos et al. 2008), and suggests that the metagranites represent the dominant source rocks of the Carboniferous monzogranites.

To identify the formation mechanism of the four Carboniferous granite bodies, U-Pb LA-ICP-MS age determinations were carried out on the zircons. CL investigations on zircons of all granites demonstrate a three-phase in-situ crystallization history. The large ratio of zircon overgrowth to core or even the absence of such cores in the Sanagasta granite indicates debut of undersaturation of Zr in the melt.

The inner seed crystallization domain is often elongated and needle-shaped with fuzzy-looking zoning. Its bright luminescence pattern implies a lower content of foreign elements, including U and Pb, than in darker overgrown younger domains. An interruption of zircon growth between seed and main domains is well documented by smoothly rounded dissolution surfaces with disruption of former growth phases. Corrosion of the seed growth phase documented by the dissolution surface marks a phase of temporary zircon-undersaturation in the melt. This implies, that, zircon-supersaturation in the newly formed melt was lower during the subsequent main crystallization phase than in the older seed crystallization phase. These observations together with Rapakivi-like textures in K-feldspar megacrysts imply a significant change in magma composition.

Mafic enclaves of the HG and the SG and further geochemical data (Grosse et al. 2008) suggest hybridization with a more primitive, possibly mantle-derived component. Zircon concentration of the mafic enclaves, which are twice as high as those of the host granites and the higher temperature of the incorporated mafic melt may have resulted in the corrosion of the pre-existing zircons in the melt. Based on U-Pb dating of zircons from all granites, the Early Achalian zircon seed growth phase is well determined at 368±2 Ma. The U-Pb zircon ages of individual granite bodies vary slightly between 371.4±5.0 Ma (SG), 369.8±4.7 Ma (eqG), 368.1±3.4 Ma (HG) and 366.0±2.7 Ma (LCS) but are identical within error (2σ).

The subsequent main zircon crystallization event is best documented in the eqG. It is the only granite in which zircons developed solely during the main crystallization phase are predominant. They are short prismatic to globular. The inner domain is bright in luminescence grading into a phase of lesser luminescence but with a regular oscillatory zoning pattern. In zircons of HG and SG only this second

growth stage is developed as an overgrowth on the seed domain. In the LCS the main zircon growth phase is nearly missing.

The change in magma composition is contemporaneous with the main zircon growth phase and has been dated at 350 ± 2 Ma (2σ; mean value; Middle Achalian) in three of the granite bodies. U-Pb zircon ages of individual granite bodies vary between 351.4 ± 3.4 Ma (eqG), 351.1 ± 6.1 Ma (LCS) and 348.6 ± 5.2 Ma (HG) but are identical within error (2σ). The age of main zircon growth period of the fourth granite, the SG, is slightly younger at 345.1 ± 5.9 Ma (2σ). This slightly younger age, combined with the geochemical and isotopic trend towards more primitive mantle compositions in the SG melt supports the idea of cumulative degree of assimilation of mantle-derived components with time in the Carboniferous granites of the Sierra de Velasco (Grosse et al. 2008). One of the youngest and most primitive products of this evolution could be the San Blas granite (340 ± 3 Ma; Dahlquist et al. 2006). Conventional U-Pb determinations on monazite from HG and SG are identical in age with that of the main zircon growth phase at 350 ± 2 Ma (Grosse et al. 2008).

Furthermore, zircons of all granites show an outer rim, prevalently without any luminescence. This black rim in the CL images is up to 40µm wide at pyramidal apices and forms the euhedral outer shape of all the crystals. The lack of any luminescence is in agreement with a very high content of foreign elements (up to 4300 ppm U). The high amount of radioactive elements (Th/U = 1 to 2.8) accounts for the damage of the crystal lattice which resulted in loss and/or gain of radiogenic lead. Reliable analyses of this outermost rim were achieved only on zircons from the LCS, because of their remarkably broad domain and a low but visible luminescence with widely-spaced oscillatory zoning. In most cases, the main growth zone is separated from the rim by a dissolution surface, as well, which supports the trend of changing melt composition with time.

Nine concordant U-Pb analyses of the outermost rims of LCS zircons yield an age of 335.7 ± 2.9 Ma (2σ). This is the youngest age determined by the LA-ICP-MS method on a single zircon growth phase in Sierra de Velasco granites and represents the very last intrusion phase, marked by small stocks. This age is somewhat younger than the corresponding monazite age (344.5 ± 1.4 Ma; Grosse et al. 2008), but similar to that of zircons from the San Blas granite obtained by conventional U-Pb analyses (334 ± 5 Ma; Báez et al. 2004).

In conclusion, the magma chamber that produced the different bodies of Carboniferous monzogranites in the Sierra de Velasco was active for about 30 Ma. During the life-span of the magma chamber, the magma composition changed progressively due to an increase of primitive mantle-derived components.

References

Báez MA, Basei MA, Toselli AJK, Rossi JN (2004) Geocronología de granitos de la sierra de Velasco (Argentina): reinterpretación de la seduencia magmática. Proc simp 40 años de geocron en Brasil 1:85.

Dahlquist JA, Pankhurst RJ, Rapela CW, Casqurt C, Fanning CM, Alasina P, Báez MA (2006) The San Blas Pluton: An example of Carboniferous plutonism in the Sierras Pampeanas, Argentina. J South Am Earth Sci 20:341-350.
De los Hoyos CR, Basei MA, Rossi JN, Toselli AJ (2008) Four new ID-TIMS U-Pb monazite ages for deformed and undeformed granitoids in the eastern sector of the Velasco range, Sierras Pampeanas, Argentina. VI SA Symp Isotope Geol Bariloche Argentina.
Grosse P, Söllner F, Báez MA, Toselli AJ, Rossi JN, de la Rosa J (2008) Lower Carboniferous post-orogenic granites in central-eastern Sierra de Velasco, Sierras Pampeanas, Argentina: U-Pb monazite geochronology, geochemistry and Sr-Nd isotopes. Int J Earth Sci online publ Feb 2008.
Höckenreiner M, Söllner F, Miller H (2003) Dating the TIPA shear zone: an Early Devonian terrane boundary between the Famatinian and Pampean system (NW Argentina). J South Am Earth Sci 16: 45-66.

Fluid inclusions and cathodoluminescence of hydrothermal breccias from the La Carolina volcanic field, San Luis, Argentina: Implications for the genesis of ore mineralization in epithermal systems

Sosa G 1, Van den Kerkhof AM 1, Urbina N 2, Gallard C 2,3

1 GZG, Universität Göttingen, Germany gsosa@uni-goettingen.de
2 Universidad Nacional de San Luis, Argentina
3 CONICET, Argentina

Introduction: The Tertiary (12-13 to 1.9 Ma) metallogenic belt of San Luis is located between latitudes 32º45'S and 33º14'S in the southeastern extreme of the Central Andean flat-slab segment between 27ºS and 33ºS. Volcanic rocks and associated ore deposits occur within a 80 km long WNW-trending belt, about perpendicular to the main reverse faults delimiting the San Luis range. The volcanic rocks intrude and overlie the Precambrian-Paleozoic basement. The main volcanic centers are (from west to east) La Carolina, Cañada Honda-Cerros Largos, Cerros del Rosario, and El Morro. The mesosilicic magmas belong to normal to high-potassium calc-alkaline and shoshonitic suites. The lithologies comprise andesites, dacites, latites, and trachytes. The rocks become progressively younger and K-rich to the east.

The La Carolina district represents a maar-diatreme system, which was disturbed by dome emplacement. Sampling includes lavas and volcanoclastic rocks. Lavas were emplaced as domes or as andesitic and latitic flows. Volcanoclastic rocks include phreatomagmatic breccias, autoclastic flow breccias and hydrothermal breccias. Gold and silver is found in base metal sulfide-rich epithermal deposits, which combine stockworks, disseminated mineralized zones, and veinlets. Mean

gold content is 0.05 ppm. The ore-bearing veinlets are commonly associated with hydrothermal and explosion breccias as well as autoclastic flow breccias (Urbina et al., 1997; Urbina, 2005). We present the results of fluid inclusion and cathodoluminescence (CL) studies on drill-core samples from the lava flow and hydrothermal breccias as well as chalcedonic breccias exposed at the present erosion level.

Petrography and cathodoluminescence: Hydrothermal breccias consist of angular fragments of volcanic rock and crystalloclasts (mainly sanidine and quartz) cemented by fine-grained material, hydrothermal quartz, calcite veinlets and sphalerite. Magmatic quartz typically shows dark blue CL and sometimes growth zoning, whereas hydrothermal quartz shows patchy pinkish CL. Carbonate veinlets contain zoned, dominantly non-luminescent crystals with thin growth zones of orange CL. Zoned sphalerite crystals show orange CL, which points at the presence of trace elements like Cu and low Fe. Euhedral pyrite and apatite (yellow CL) are disseminated in all rocks. The chalcedony breccia is characterized by 3 generations of chalcedony, formed around rock fragments and crystalloclasts. Chalcedony I shows depositional banding, whereas chalcedony II is massive and light gray. Both contain accessory calcite (bright orange), adularia (blue) and apatite (green CL). Darker chalcedony III is non-luminescent with less accessory minerals. Chalcedony III is associated with carbonate veinlets and druses, which contain from the wall inwards fine-grained carbonate with orange CL, zoned non-luminescent carbonate, and coarse-grained carbonate with mainly yellow CL. Disseminated pyrite is present in all minerals, but more abundant in carbonate. Organic components (gastropods?) in chalcedony points at sub-surface (lacustrine?) conditions during the latest mineralizing phase.

Breccias and chalcedony are largely effected by argillic alteration. Particularly the feldspars (plagioclase with brownish CL) are strongly altered. The secondary clay minerals can be clearly recognized by their deep blue CL.

Fluid inclusions: Fluid inclusions occur in sanidine, magmatic quartz, hydrothermal quartz and sphalerite.

Sanidine contains well-developed primary H_2O-NaCl-$CaCl_2$-KCl inclusions (Type 1) with high salinity (18 to >41wt% NaCl-equiv.), which often have one large halite crystal or sometimes more daughter phases. These inclusions typically show elongated negative crystal shapes (mean size ca. 45x10 μm). Ice melting for inclusions with or without daughter crystals was observed between -45 and -15°C (typically around -40°C). The melting of a salt hydrate (probably antarcticite or sinjarite) takes place at relatively high temperatures (between +23 and +40°C). Raman analysis demonstrates that CO_2 (or any other gas) is absent. Homogenization temperatures range between 230 and 390°C, always to liquid. The salt crystal dissolves at 213-269°C, always shortly before homogenization.

Magmatic quartz contains H_2O-NaCl-$CaCl_2$-KCl (Type 1), H_2O-CO_2-N_2-NaCl (Type 2), CO_2-N_2 (Type 3), and H_2O-NaCl (Type 4) inclusions. Type 1 inclusions are generally larger (ca. 9x16 μm) than the other types (ca. 5x10 um). Type 1 inclu-

sions are primary, have high salinity (22-42 wt% NaCl-equiv.) and contain typically 3 daughter phases (halite, hematite as identified by Raman spectroscopy, and probably sylvite). Like the Type 1 inclusions in sanidine, CO_2 is absent. Ice melting was observed between -45 and -19°C, but salt hydrates were not observed here. The homogenization temperatures (Th) are >600°C and could not be measured.

Type 2 inclusions show varying water volume fracs (0.05-0.9) and intermediate salinity (5-13 wt% NaCl-equiv). The gas fraction contains CO_2-N_2 with up to 30% N_2 and sometimes traces of CH_4 (≤0.2%) as measured by Raman analysis. Eutectic temperatures indicate NaCl dominant solutes. Th to vapor or liquid ranges between 176 and 444°C.

Type 3 inclusions contain CO_2-N_2 with up to 13% N_2, traces of methane and no detectable water. Sulfuric components like H_2S or HS^- could not be detected in any inclusion type.

Type 4 aqueous inclusions have lowest salinity of ~3 wt% NaCl-equiv. Th to liquid between 248 and 328°C. The hydrothermal quartz and sphalerite contain exclusively Type 4 inclusions.

In the chalcedony breccia only relatively small (3 x 4 m) primary Type 4 aqueous inclusions could be found in calcite. They have low salinity (~2 wt% NaCl-equiv) with homogenization temperatures at 130-360°C; always to liquid.

Conclusion: Fluid inclusions clearly differentiate between high-saline, CO_2-free magmatic fluids (Type 1 inclusions in sanidine and quartz) and low-saline hydrothermal fluids (Type 4 inclusions in quartz, calcite, and sphalerite). The N_2-bearing aqueous-carbonic inclusions (Type 2) may represent boiling and mixing of the deep-saline brines with meteoric water. Low-salinity aqueous and gas inclusions (Type 3 and 4) are likely the result of immiscibility towards lower temperatures.

The magmatic temperatures exceeded 600°C, but the main mineralization must have taken place at much lower temperatures (230-330°C). Fluid inclusions in late-stage quartz and sphalerite indicate temperatures of ca. 280°C. The latest hydrothermal activity at ca. 260°C is represented by aqueous inclusions in calcite from the chalcedonic breccia.

Fluid inclusions suggest that the original NaCl-$CaCl_2$-KCl-bearing magmatic brines must have been enriched in water, CO_2, and N_2 by the assimilation of subducted sediments. Giggenbach (1992) assumed that only ca. 1 percent of the water and <20 percent of the CO_2 and N_2 in vapors associated with andesitic magmatism are of mantle origin. Once entrained into the rising andesitic magma, the volatiles will react with one another and the rock in response to decreasing temperatures and pressures to produce the variety of gases encountered at the surface (and in fluid inclusions) in volcanic and geothermal areas.

References

Giggenbach WF (1992) Magma degassing and mineral deposition in hydrothermal systems along convergent plate boundaries. Economic Geology 87: 1927–1944

Urbina N. E., Sruoga P. and Malvicini L. 1997. Late Tertiary Gold-Bearing Volcanic Belt in the Sierras Pampeanas of San Luis, Argentina. International Geology Review. 39 (4): 287-306.
Urbina NE (2005) Cenozoic magmatism and mineralization in the Sierras Pampeanas of San Luis, Argentina. Rhoden H N, Steininger R C, Vikre P G (eds.) Geological Society of Nevada Symposium 2005, Reno, Proceedings 2: 787-796

The origin of coastal boulder deposits in the southern Caribbean: hurricane versus tsunami - a sedimentological assessment

Spiske M 1, Böröcz Z 2, Bahlburg H 1

1 Westfälische Wilhelms-Universität, Geol-Paläontol.Institut, Correnssstr. 24, 48149 Münster, Germany, spiske@uni-muenster.de

2 Westfälische Wilhelms-University, Laboratory of Biophysics, Robert-Koch-Strasse 45, 48149 Münster, Germany

Coastal boulder deposits are a subject of controversial discussions (Hearty, 1997; Bourrouilh-Le Jan, 1998; Scheffers & Kelletat, 2003; Spiske et al., 2008). Without doubt, these sedimentary features are a consequence of high-energy wave impacts. Nevertheless a clear discrimination whether these deposits are due to storm, hurricane or tsunami impacts can not be made easily. The main distinguishing parameters between storm, hurricane and tsunami origin are the distance of a deposit from the coast, boulder weight and inferred wave height. Formulas to calculate minimum wave heights of both storm and tsunami waves depend on accurate determination of boulder dimensions and lithology from the respective deposits (Nott, 1997; Nott, 2003). At present however, boulder porosity appears to be commonly neglected, leading to significant errors in determined bulk density, especially when boulders consist of reef or coral limestone. This limits precise calculations of wave heights and hampers a clear distinction between storm, hurricane and tsunami origin. Our study (Spiske et al., 2008) uses Archimedean and optical 3D-scanning measurements for the determination of porosities and bulk densities of reef and coral limestone boulders from the islands of Aruba, Bonaire and Curaçao (ABC Islands, Netherlands Antilles). Due to the high porosities (up to 68%) of the enclosed coral species, the weights of the reef rock boulders are as low as 20% of previously calculated values. Hence minimum calculated heights both for tsunami and hurricane waves are smaller than previously proposed. We show that hurricane action seems to be the likely depositional mechanism for boulders on the ABC Islands, since 1) our calculations result in tsunami wave heights which do not permit the overtopping of coastal platforms on the ABC Islands, 2) boulder fields lie on the windward (eastern) sides of the islands, 3) recent hurricanes transported

boulders up to 35 m^3 and 4) the scarcity of tsunami events affecting the coasts of the ABC Islands compared to frequent impacts of tropical storms and hurricanes.

References

Bourrouilh-Le Jan F. G. (1998)The role of high-energy events (hurricanes and/or tsunamis) in the sedimentation, diagenesis and karst initiation of tropical shallow water carbonate platforms and atolls. Sedimentary Geology 118: 3-36.

Hearty J.P. (1997) Boulder deposits from large waves during the last interglaciation on North Eleuthera Island, Bahamas. Quaternary Research 48: 326-338.

Nott J. (1997) Extremely high-energy wave deposits inside the Great Barrier Reef, Australia: determining the cause - tsunami or tropical cyclone. Marine Geology 141: 193-207.

Nott J. (2003) Waves, coastal boulder deposits and the importance of the pre-transport setting. Earth and Planetary Science Letters 210: 269-276.

Scheffers A., Kelletat D. (2003) Sedimentologic and geomorphologic tsunami imprints worldwide – a review. Earth-Science Reviews 63: 83-92.

Spiske M., Böröcz Z., Bahlburg H. (2008) The role of porosity in discriminating between tsunami and hurricane emplacement of boulders - a case study from the Lesser Antilles, southern Caribbean. Earth and Planetary Science Letters 268: 384-396.

Sedimentological aspects of recent and historical tsunami events along the coast of Peru

Spiske M 1, Piepenbreier J 1, Benavente C 2, Bahlburg H 1, Kunz A 3, SteffahnJ 4

1 Westfälische Wilhelms-Universität, Geologisch-Paläontologisches Institut, Corrensstrasse 24, 48149 Münster, Germany, spiske@uni-muenster.de

2 Instituto Geológico, Minero y Metalúrgico INGEMMET, Av. Canadá 1470, Lima, Perú

3 Institut für Geowissenschaftliche Gemeinschaftsaufgaben GGA, Geozentrum Hannover, Stilleweg 2, 30655 Hannover, Germany

4 Universidad Autónoma de Nuevo Léon, Facultad de Ciencias de la Tierra, Carretera Cerro Prieto Km 8, 67700 Linares, México

The coast of Peru is greatly endangered by tsunami events. The subduction of the Nasca Plate below the South American Plate triggers strong submarine earthquakes that are capable of causing tsunami.

High-energy wave events are major coast shaping processes. In some regions, e.g. the Caribbean, a distinction between storm/hurricane and tsunami deposits is difficult. Therefore, the absence of heavy storms makes the Peruvian coast a good target for tsunami research. Other meteorological phenomena, like El Niño events that occur in Peru are not associated with strong storms or surges. Deposits of El

Niño-caused flooding can easily be distinguished from tsunami events, since their sedimentary structures imply transport from the land to the sea, the deposited material derives from the mountain ranges and no indicators (e.g., foraminifera, shells) of marine inundations are present.

In our study we re-surveyed locations of the three most recent regional tsunami events in order to learn about the sedimentary structures and their preservation potential. We visited the areas affected by the Chimbote-Tsunami of 21st February 1996 (5 m run up; Bourgeois et al., 1999; Kulikov et al., 2005), by the Camana-Tsunami of the 23rd June 2001 (9 m run up; Jaffe et al., 2003) and by the Pisco-Paracas-Tsunami of 15th August 2007 (10 m run up; Fritz et al., 2007). Secondly, we surveyed the coast of Peru in order to find traces of historical or paleotsunami events. All sediments were sampled for grain size analysis, foraminifera determination and optically stimulated luminescence dating. For historical events, the inverse tsunami model of Jaffe & Gelfenbaum (2007) was applied to calculate onshore tsunami flow depths.

Both recent and historical tsunami deposits are present as (1) (graded) layers of coarse sand, some including shell fragments or pieces of rock, (2) (imbricated) shell layers, (3) heavy mineral accumulations and (4) mud caps or mud balls. Imbricated shells can give information on flow directions and hence can help to distinguish between run up and backwash sediments.

Unfortunately, the preservation potential of onshore tsunami deposits is very low. Erosion by wind, rivers or heavy rain falls (e.g., during El Niño events) and bioturbation (e.g., by crabs) can modify or destroy the sediments. For recent events, human activity (e.g., the use of beach / tsunami sand for rebuilding) is a limiting preservation factor. This study shows that muddy tsunami sediments and backwash sediments have the highest preservation potential. This is due to the cohesion of mud that makes the deposits less sensitive for erosion during backwash and due to fast hardening of mud layers in the dry Peruvian climate.

References

Bourgeois J., Petroff C., Yeh H., Titov V,. Synolakis C. E., Benson B., Kuroiwa J., Lander J., Norabuena E. (1999) Geologic setting, field survey and modeling of the Chimbote, Northern Peru, Tsunami of 21 February 1996. Pure Applied Geophysics 154: 513-540.

Fritz H. M., Kalligeris N., Ortega E., Broncano P. (2007) 15 August 2007 Peru tsunami runup and inundation.
http://www.eeri.org/lfe/pdf/peru_coast_tsunami.pdf

Jaffe B., Gelfenbaum G., Rubin D., Peters R., Anima R., Swensson M., Olcese D., Anticona L. B., Gomez J. C., Riega P. C. (2003) Identification and interpretation of tsunami deposits from the June 23, 2001 Peru tsunami. Proceedings of the International Conference on Coastal Sediments 2003, CD-ROM published by World Scientific Corp and East Meets West Production, Corpus Christi, Texas, USA.

Jaffe B. E., Gelfenbaum G. (2007) A simple model for calculating tsunami flow speed from tsunami deposits. Sedimentary Geology 200: 347-361.
Kulikov E. A., Rabinovich A. B., Thomson R. E. (2005) Estimation of tsunami risk for the coasts of Peru and Northern Chile. Natural Hazards 35: 185-209.

A new fossil *lagerstätte* for ichthyosaurs of early Cretaceous age in the Torres del Paine National Park, Southernmost Chile

Stinnesbeck W 1, Pardo Pérez J 1, Salazar Soto C 1, Leppe CarteM 2, Frey E 3

1 Institut für Geowissenschaften, Universität Heidelberg, Im Neuenheimer Feld 234-236, 69221 Heidelberg. stinnesbeck@uni-heidelberg.de
2 Instituto Antárctico Chileno, Punta Arenas, Chile
3 Staatliches Museum für Naturkunde Karlsruhe; Erbprinzenstraße 13, 76133 Karlsruhe

Platypterygian ichthyosaurs recently discovered in the Torres del Paine National Park of Chile represent the southernmost and stratigraphically youngest and most complete specimens of this group worldwide. Within only one week of fieldwork in February 2007, we located 15 articulated and subcomplete skeletons, both adults and juveniles, associated with ammonites, belemnites, inoceramid bivalves and teleostid fishes. The assemblage was deposited in monotonous siliciclastic flysch lithologies of the now closed Rocas Verdes back-arc basin. This enormous concentration of marine Mesozoic reptiles to present knowledge appears to be unique for Chile and South America and will certainly place the locality among the prime fossil *lagerstätten* for Jurassic-Cretaceous marine reptiles in the world. We have begun to investigate taxonomy, biostratigraphy and palaeobiogeography of the Torres del Paine ichthyosaurs and associated fossil assemblage. Our research further aims to evaluate the conditions, which led to the excellent preservation and concentration of marine vertebrates in this enigmatic fossil deposit.

Massive use of GIS for Natural Hazard Assessment on 90 low-cost house building projects in Nicaragua

Strauch W 1, Muñoz A 2, Blanco M 3, Collado C 2, Castellón A 2, Acosta N 1

1 Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Project on Mitigation of Georisks in Central America, wilfried.strauch@yahoo.com
2 Instituto Nicaragüense de Estudios Territoriales (INETER), Managua, Nicaragua
3 Universidad Nacional de Ingeniería (UNI), Managua, Nicaragua

In Nicaragua, the Institute of Urban and Rural Housing (INVUR) and the Social

Housing Funds (FOSOVI) are responsible for solving the housing problem especially for the low-income sectors of the population. To fulfill their mission in terms of safety of the new houses, these institutions have requested technical support to the Nicaraguan Institute of Territorial Studies (INETER-Geosciences Institute) for the assessment and mapping of geological and hydro-meteorological hazards at sites selected by local governments for the construction of houses. The aim of the hazard mapping was to identify and assess hazards and define hazard levels of natural phenomena like seismic events, volcanic eruptions, tsunamis, landslides, hurricanes, inundations which may impact on the infrastructure and affect the residents of the new houses. Hazard definitions and acceptable hazard levels were defined according legal regulations, previous regional hazard studies, and methodological agreements between the different technical groups working on hazard assessment in Nicaragua. The responsibility for the execution of the work was given to the General Directorate for Geophysics at INETER. Given the large number of sites which had to be assessed, an efficient working scheme had to be developed based on the extensive information available in the archives of INETER and the use of modern GIS methods: 1) Groups of specialists were formed (geologist, hydrologist, GIS specialist) who worked in parallel on the different sites; 2) Existing data on the technical archive of INETER were revised; 3) The sites were visited and local information was gathered; 4) The GIS on Georisks at INETER was used to develop the hazard maps; 5) The technical report was prepared; 6) The products were reviewed by the corresponding technical areas of INETER.

In several phases, from 2004 to 2008, the natural hazards in more than 90 sites with a total of around 7000 houses throughout Nicaragua were investigated. The execution time was about 1 or 2 weeks per site, in some complex cases - some weeks. Sometimes the access to the site was difficult and time consuming due the precarious logistic situation especially in the Atlantic part of the country. The sites had been previously selected by the corresponding municipalities for the construction of low-cost houses, most of them in rural areas. Each site covered between 50 to 200 homes, normally concentrated in a single spot, but sometimes the houses are dispersed in the municipality. The location of each house was inspected to evaluate its specific situation, e.g. the distance to rivers banks or possibility of the affectation due to currents in case of strong rains. Landslide and inundation hazard, in coastal area tsunami hazard, required the most intensive field work. In some cases seismic soil amplification and active faulting had to be investigated to assess the seismic hazard.

In several cases the location of single houses or groups of houses had to be rejected, in other cases the construction location was accepted but preventive measures were recommended. In one case, the whole housing project was rejected because the complete site was located on an active, slowly moving landslide which would have affected or destroyed the houses within some years. The municipality had to buy another terrain for the construction project.

For each site about 10 to 12 maps (1:1000, 1:5000, 1:50000), a technical report

and a specific GIS (ArcGIS format) were elaborated that means, that in total, more than 900 maps, 90 reports and 90 GIS were produced. Reports and maps were delivered in hard copy and in digital format to INVUR and to the local authorities corresponding to the site. The work was done in close cooperation with the local municipalities and technical staff of INVUR. The products are available on the website INETER. More than 7000 Nicaraguan families know that their new homes are built under an acceptable hazard level.

References: http://www.ineter.gob.ni/geofisica/proyectos/INVUR/index.html

---

GIS based Natural Hazard Assessment for three zones proposed for the construction of a new refinery at the Pacific Coast of Nicaragua

Strauch W 1, Muñoz A 2, Mayorga E 2, Castellón A 2, Acosta N 1, Montoya I 2, Rosales M 2

1 Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Project on the Mitigation of Georisks in Central America, Managua, Nicaragua, email: wilfried.strauch@yahoo.com

2 Instituto Nicaragüense de Estudios Territoriales (INETER), Managua, Nicaragua, alex.castellon@gf.ineter.gob.ni

As part of a multidisciplinary feasibility study for the construction of a new refinery at the Pacific coast of Nicaragua an assessment of natural hazards was made, in June 2007,for three possible sites known as: Cabo Desolado (El Transito), Miramar and El Tamarindo (ENASAL). The integrated analysis of geological hazards (earthquakes, volcanic eruptions, tsunamis, landslides) and hydro-weather (dizzy, floods, currents, hurricanes, heavy rains). The analysis was based largely on the results of a large number of previous studies which are now covered by an integrated Geographic Information System (GIS) on Georisks developed and maintained by INETER.

GIS was used to make maps of the three sites in question and to analyze the advantages and disadvantages of each site in terms of natural hazard. The seismic hazard due to large earthquakes occurring in the subduction zone of Nicaragua represents the the biggest problem for the sites. for a period of 50 years The peak acceleration (PGA) on rock could reach around 4 ms^{-2} with a probability of 90%. A large tsunami has hit, in September of 1992, the coastal area in question with 4 to 10 meter high waves. The possible repetition of the latter phenomenon represents a special hazard to infrastructure foreseen for the unloading of petroleum and loading of final products from products of the proposed refinery. Other phenomena, as hurricanes or affectation by volcanic ash from eruptions in the nearby Nicaraguan volcanic chain are less likely or significant but have be taken into account in the design and construction of the planned refinery.

The results of this study were combined with other works on environmental issues and land use management to support the process of decision making on the most favorable site for the construction of the refinery.

Contribution to Early Warning on landslides in Central America using precipitation estimates from meteorological satellite data in real time

Strauch W 1, Castellón A 2,

1 *Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Project on the Mitigation of Georisks in Central America, Managua, Nicaragua, email: wilfried.strauch@yahoo.com*

2 *Instituto Nicaragüense de Estudios Territoriales (INETER), Managua, Nicaragua, alex.castellon@gf.ineter.gob.ni*

A software system was developed to present in near real time estimates for strong precipitation provided by the experimental Hydroestimator (NESDIS/NOAA) which is based on meteorological satellite data in near real time. Local maps, tables and curves present the behavior of the accumulated rainfall at certain sites, in the last 1, 3, 6, 12 and 24 hours. Also, real time data of existing rain gauges are presented. The easy access to all this information is of much practical use for disaster managers in the Central American countries.

Strong rainfalls related to tropical storms, frequently, cause landslides and inundations in Central America. In the region, meteorological stations are sparse and weather radars do not exist. Thus, any alternative information is highly welcome to institutions responsible for monitoring, and early warning as meteorological and geosciences agencies, emergency commissions and local authorities.

Imminent landslide occurrence is assumed applying global satellite-based rainfall intensity-duration threshold curves for triggering landslides. For some "hot spots" local thresholds are used. The system is able to send out automatically warning messages by email.Parts of the NESDIS data base are mirrored twice an hour and the data can be processed by simple GrADS scripts. Works are going on to validate rain estimates to develop more local threshold curves for sites in Central America. Case studies are discussed to illustrate the usefulness of the method.

References

Devoli , Strauch , Chávez , Høeg (2007) A landslide database for Nicaragua: a tool for landslide-hazard management, Landslides DOI 10.1007/s10346-006-0074-8

Devoli , Morales & Høeg (2006) Historical landslides in Nicaragua—*collection and analysis* of data, Landslides, DOI 10.1007/s10346-006-0048-x

Nadim, F., O. Kjekstad, P. Peduzzi, C. Herold, C. Jaedicke (2006), Global landslide and avalanche, hotspots, *J. Landslides, 3(2), 159–173,* doi:10.1007/s10346-006-0036-1.

Hong Y., Adler R.E., Huffmann G.J. (2007). Satellite Remote Sensing, for Global Landslide Monitoring, Eos, Vol. 88, No. 37, 11 September 2007

Ferraro, R., G. A. Vicente, M. Ba, A. Gruber, R. Scofield, Q. Li and R. Weldon (1999) Satellite Techniques Yield Insight into Devastating Rainfall from Hurricane Mitch. EOS, Transaction, AGU, Vol. 80, No. 43, 10/26/1999, 512-514

Vicente, G.A. Scofield R. A. and Menzel, W.P. (1998) The Operational GOES Infrared Rainfall Estimation Technique, edition of the Bulletin of American Meteorological Society, September 1998

REE and major elements analyses in volcanic lithoclasts of pyroclastic rocks with EDS and laser ablation (LA-ICP-MS) techniques. Planchadas Fm., Famatina System, Argentina

Such P 1, Castro A 2

1 INSUGEO – CONICET. Facultad de Ciencias Naturales e Instituto Miguel Lillo, Universidad Nacional de Tucumán, Argentina. suchpamela@hotmail.com

2 Depart. de Geología, Universidad de Huelva, Campus del Carmen, 21071 Huelva, Spain

The Planchadas Fm. corresponds to a volcanic complex erupted during Ordovician age. It is composed by pyroclastic deposits, intrusive domes, lava flows, and reworked and redeposits pyroclastic rocks. These rocks outcrop in the southern end of the Las Planchadas range, in the Famatina System, (Catamarca Province, northwestern Argentina) and their origin and relation to the sedimentary Suri Fm. have been object of controversy for years. This work is focused on the determination and study of the geochemical composition of volcanic and unknown lithoclast contained in some of the pyroclastic rocks. These lithoclasts are important to understand the composition of the erupted rocks. In some cases they are observed to be rhyolitic and rhyodacitic rocks, opposing what some authors (Cisterna, 2008) have stated about the existence of basic rocks in the complex (e. g.. basalt).

The determinations of REE and major element compositions were done by energy-dispersive spectrometry (EDS , attached to a scanning electron microscope (SEM, and by laser ablation (LA attached to an ICP-MS equipment . Major elements where analyzed with SEM at the Marie Curie Laboratory in the Huelva University (Spain .The lithoclast to be analyzed in the electron microscope where selected by previous detailed petrographic microscopic studies. The REE where determined with laser ablation by the LAICP-MS in the laboratory of Granada University.

This study yields that the composition observed in the lithoclastic rocks corresponds to andesites, with a large content of plagioclase showing a trachyte texture

in most cases. In other cases, "amygdaloidal" textures resembling pillowed andesites were observed. The REE patterns observed here also correspond to magmatic rocks with andesitic characteristics. In this case, it was necessary to eliminate the FeO excess of the lithoclast for this study. The rocks where exposed to long-lived alteration processes by both meteoric and hydrothermal fluids. These fluids refilled the amygdales, replacing and filling throughout the whole matrix with abundant chlorite. The resulting excess FeO was estimated at the SEM and eliminated in the final analysis.

Geochemistry of Ordovician volcanic domes of the Las Planchadas Fm, Famatina System, Argentina

Such, P 1, Castro A 2, Aceñolaza FG 3

1 INSUGEO – CONICET. Facultad de Ciencias Naturales e Instituto Miguel Lillo, Universidad Nacional de Tucumán, Argentina. Email: suchpamela@hotmail.com

2 Departamento de Geología, Universidad de Huelva, Campus del Carmen, 21071 Huelva, Spain. E-mail: dorado@uhu.es

3 INSUGEO-CONICET; Facultad de Ciencias Naturales e Instituto Miguel Lillo, Universidad Nacional de Tucumán, Argentina. E-mail: facenola@infovia.com.ar

The studied area is located in the southern end of the Las Planchadas Range, to the northwest of the Famatina System. The area corresponds almost completely to Ordovician rocks of the Suri (Harrington y Leanza, 1957) and Las Planchadas (Turner, 1967) formations. These formations are represented by shallow marine and volcaniclastic sediments interbeded with pyroclastics, lava domes, lava flows and fallout deposits respectively. Las Planchadas Fm. is mainly composed of andesitic rocks which are interbeded with rhyolitic pulses and subordinated sub aqueous breccias (Toselli *et al*, 1993; Cisterna, 2001). They are believed to occur towards the top of the Ordovician succession (Aceñolaza y Toselli, 1984, 1988). Recently, Baldo *et al* (2003) dated ryolithic porphyritic rocks of the Las Planchadas Range that where found interstratified with marine sediments of the Suri Formation, the 206Pb/238U ages obtained where 468.3 +- 3.4 Ma, making this a late Arenig event.

Both formations are related to the Gondwana margin evolution in South America during Early Ordovician times. Its chemical composition varies from rhyolites, rhyodacites to andesites. These compositional variations occur during individual stages, however, the overall pectrographic and compositional characteristics remain constant in time. Abundant lava domes are characterized by banded glasses and perlitic textures towards the base. They form dome-like structures in the

sediments in which that they intruded. They outcrop in large areas with varying sizes. The compositions mayor elements and RRE of the domes was studied with EDS and ICP-MS techniques respectively, laser ablation was the technique selected for this study. This technique made possible to get point analyses the individual layers in rock thin sections. The mayor elements analysis has shown compositional variation within each band, ranging from rhyolite to rhyodacite in composition. The RRE analysis shows coherent patterns; heavy RRE enrichment is normally observed. These results could correspond to accessory minerals such as xenotime. In most trace elements a significant enrichment in incompatible mobile elements (LIL, large-ion lithophyle) is observed. When the data are normalized to reference standards such us MORB or primitive mantle; similar coherent patterns are obtained. A significant enrichment in the incompatible immobile elements is observed, this would indicate the existence of some arc magmatism signature, however, the enrichment in immobile smaller ionic radius elements (Y, Zr, and heavy RRE) is not compatible with such type of magmatism.

References

Aceñolaza, F. G. y Toselli, A. (1984) Lower Ordovician Volcanism in Northwest Argentina. In: Aspects of the Ordovician System. Brunton D.L. Ed., pp: 203 – 209.

Aceñolaza, F. G. y Toselli, A. (1988) El Sistema de Famatina como unidad orográfica de interés geológico. Informe PID-CONICET. Geología del Sistema de Famatina. Inédito.

Baldo, E. G., fanning, D. M., Rapela, C. W., Pankhurst, R. J., Casquet, C., Galindo, C. (2003) U-Pb Shrimp dating of rhyolite volcanism in the famatinan belt and K-bentonites in hte Precordillera. In: Albanesi, G. L., Beresi, M. S., Peralta, S. H. (Eds.): Ordovician from the Andes, Serie Correlacion geologica, 17, 41 – 46.

Cisterna, C. E. (2001) Volcanismo subácueo en el Eopaleozoico del Sistema de Famatina, Noroeste de Argentina. Revista de la Asociación Geológica Argentina, 56 (1) : 16-24.

Harrington, H. J. y Leanza, A. F. (1957) Ordovician trilobites of Argentina. University of Kansas, Special Publication, 259 p. Kansas.

Toselli, A. J., Rossi de Toselli, J., Pelletero, E., y Saavedra, J. (1993) El Arco magmático granítico del Paleozoico Inferior en el sistema de Famatina, Argentina. Actas 12º Congreso geológico Argentino y 2º Congreso de Exploración de Hidrocarburos, 4: 7 -15. Mendoza.

Turner, J. C. M. (1967) Descripción geológica de la hoja 13b Chaschuil, Provincia de Catamarca y La Rioja. Bol. Inst. Nacl. Geol. Miner., 106.

The explosive phases of Jorullo Volcano, the first historic eruption in Mexico

Sumita M , Schmincke H-U,

FB4, IFM-GEOMAR FZ, Germany. msumita@ifm-geomar.de, h-u.schmincke@t-online.de

The Jorullo Volcano (JV) group (1759 - 1774) became famous through Alexander von Humboldt's 1809 report on hornitos on the lava flows. Our aim is to reconstruct the dynamic history of the eruption based on a detailed stratigraphic, lithological and compositional analysis of the tephra blanket, extending previous in-depth petrologic studies on the lavas (Luhr and Carmichael, 1985), on ol-melt inclusions in 3 tephra layers (Johnson et al., 2008) and ongoing work by Siebe et al. on the lavas.

Stratigraphy: We have provisionally subdivided the proximally up to ca. 8 m thick tephra blanket (hundreds of mostly thin layers) into 6 major episodes based on layers rich in lithics, coarse-grained fallout tephra, beds or intervals of extremely fine-grained tuffs and erosional unconformities and correlated these to outcrops beyond the periphery of the lava flow field, up to >4 km NW of JV. Individual beds can be traced not only radially but also laterally, e.g. from Agua Blanca 4 km west to El Guayabo Colorado 3 km north of JV, contrasting with the mostly radial distribution of individual ash layers at Paricutin (Pioli et al., 2008), which greatly resemble those at JV. Episode I, the initial distinctive unit (10-40 cm thick), is regionally channeled, possibly the result of the November 1759 hurricane reported in the literature. These are fine-grained, locally finely laminated to cross-laminated (?), indurated white and pink-colored alternating layers of mainly phreatomagmatic origin (accretionary lapilli, vesicle tuff, and abundant basement lithoclasts). Episode II (proximally ca. 2 m) is represented by bedded, dominantly moderately to poorly sorted tephra, subdivided by two characteristic pink-colored and one whitish lithoclast-rich layer ending with an up to 50 cm thick interval of some 20 fine-grained ash layers representing a largely impermeable surface subsequently strongly channeled. Episode III (1-1.5 m thick proximally) contains the 3 mostly coarse-grained fallout beds (dominantly tan vesicular lapilli with characteristic "tostada/tortilla"-shapes). Strongly bedded tephra of episode IV is rich in subround granodiorite/granite possibly also epiclastic lithoclasts, also common as inclusions in juvenile clasts in overlying layers. A >2m thick top unit (episode V), dominantly eroded, is characterized mostly by massive layers but will likely be subdivided during further work. Entirely reworked tephra (episode VI) (fragments of dense glassy phreatomagmatic bread crust bombs) forms a local apron along at least the eastern and southern lower to middle slopes of JV.

Particles: At least 5-10 different types of juvenile particles can be distinguished from each other. They range in color from black tachylite through deep brown, brown, light brown to colorless and glassy, from non-vesicular to highly vesicular and from blocky angular to smooth, surface tension-controlled. Highly vesicular

(>50 vol %) shards and lapilli are most common in the few major distinct well-sorted fallout layers, up to 30 cm thick proximally, in which highly vesicular "tortilla/tostada"-shaped flat lapilli up to ca. 5 cm in diameter are particularly prominent. Non-vesicular blocky to slightly vesicular ash particles dominate in the size fractions < 1mm. However, juvenile clasts > ca. 1 mm allow to better estimate vesicularity than smaller clasts which represent fragments of lapilli. Nevertheless, the bulk of tephra is <1mm in diameter indicating extreme degrees of fragmentation and recycling throughout much of the eruption. Light-colored juvenile colorless glass shards studded with plagioclase microlites are commonly much more vesicular than the black tachylite and those with various shades of brown. Silt-sized fraction is minor. Olivine (5-10 vol. % in the lavas) is concentrated in the ash fraction of many tephra layers. This high degree of fragmentation of new magma and tephra/lava resident in the conduit is probably due to the high water content of the magma (5.3 wt. % in olivine melt inclusions in the most primitive early magma (Johnson et al., 2008)) and the high crystallinity of the tephra (abundance of plagioclase microlites).

Magma-water interaction: Frequent interaction with external water is reflected in a) common granitic-granodioritic lithoclasts, b) cored and packed accretionary lapilli and c) vesicle tuffs with some fine-grained poorly sorted beds and massive beds probably representing rapidly disintegrated accretionary lapilli. Nevertheless, pyroclastic fragmentation prevailed throughout much of the violent Strombolian eruptions, very high H_2O concentrations in olivine melt inclusions (Johnson et al., 2008) and advanced groundmass crystallization (fsp microlites) probably governing the high explosivity. Fallout was the dominant mode of sedimentation. At least 4 major intervals of lithoclast-rich (dominantly variously altered granitic to granodioritic plutonics, mica (ranging from altered to fresh individual crystals) and minor sediments reflect distinct breaks in the eruptive history and represent some of the best regional marker horizons.

Evolution of magma composition and modes of eruption: One major problem in monitoring vertical changes in composition is the fact that most tephra layers are made of mixed clast populations owing to common recycling in the conduit. For example, olivine crystals showing different types of matrix rims (colorless, light to dark brown, dark tachylitic), probably representing different stages of the eruption, occur in the same tephra layer. We confirm the more evolved late stage basaltic andesite lava differing in mineralogy and chemistry from the early mafic lava (Luhr and Carmichael, 1985) and add a late dike containing abundant deformed cpx microphenocrysts and cpx clusters and minor olivine. Our EMP data on glass shards from some 30 tephra layers show distinct trends toward more evolved compositions with time (see also Johnson et al., 2008). However, due to ubiquitous recycling, olivine and shards are mixed in many layers. Explosive and effusive activity of Jorullo clearly alternated: tephra was deposited prior to the first lava flow, which overlies and has baked some 2 m of tephra at the flow terminus near Agua Blanca. Tephra covering later lava flows probably fell in 2 (?) distinct episodes on lavas of

different age while tephra is lacking on the youngest flow in the north. Our preliminary data show that the magma volume represented by the tephra blanket (JT) may exceed that of the lavas. A stonewall covered by thick tephra at the terminus of the first lava near Agua Blanca may be part of the "Hacienda" compound abandoned during the eruption. Careful excavation may reveal important details on the effects of the eruption.

Supported by AvH Foundation (institutional cooperation with UNAM).

References

Johnson ER, Wallace PJ, Cashman KV, Delgado Granados H, Kent A (2008) Magmatic volatile contents and degassing-induced crystallization at Volcán Jorullo, Mexico. Implications for melt evolution and the plumbing systems of monogenetic volcanoes. Earth Planet Sci Let 269: 478-487

Luhr, JF, Carmichael, ISE (1985) Jorullo Volcano, Michoácan, Mexico (1759-1774): the earliest stages of fractionation in calc-alkaline magmas. Contrib Mineral Petrol 90: 142-161

Pioli L, Erlund E, Johnson E, Cashman K, Wallace P, Rosi M, Delgado Granados H (2008) Explosive dynamics of violent Strombolian eruptions: The eruption of Parícutin Volcano 1943-1952 (Mexico). Earth Planet Sci Let 271: 359-368

Analysis of drainage anomalies as a tool to elucidate neotectonic soft-linked deformation zones.

Terrizzano C, Cortés JM

Laboratorio de Neotectónica (LANEO), Universidad de Buenos Aires, Argentina. cterrizzano@gl.fcen.uba.ar

At the Central Andes, between 31° and 34° SL, the paleotectonic features represented by sutures zones between allochtonous Paleozoic terranes and branches of Mesozoic extensional basins concentrate much of the Quaternary and active deformation. At 32º SL, the Cuyana basin northern segment, which is Triassic in age, controls the location of seismically active NW trending morphotectonic units. At this location, the northwestern piedmont of the Precordillera Sur (Cortés et al. 2005) has been uplifted during the Quaternary (Cortés y Costa 1993, Cortés y Cegarra 2004, Terrizzano 2006a,b) through folds, blind faults, shear faults and faulted blocks that form discrete areas of brittle and brittle-ductile shear zones at different scales (Terrizzano et al. 2008).

This contribution analyzes the geomorphic and structural features located at the piedmont of the El Naranjo and Ansilta ranges, northwestern Precordillera Sur

(31º 40´ - 32 º 20´ SL) in order to characterize such Pleistocene to Recent piedmontal tectonic geophorms.

Contractional active deformation of Quaternary alluvial deposits in piedmont environments becomes evident not only because of an accentuated relief modification but also thanks to subtle perturbations of fluvial geomorphologic elements. On the one hand, at the piedmont plains of the northwestern Precordillera Sur, the cumulative deformation associated to growth structures develops tectonically controlled topographic highs (TH) characterized by definite and clear borders, lineal, trapezoidal or irregular design at surface. This phenomenon takes place when the tectonic uplift rate is greater than the erosion and sedimentation rate. These features are mainly related to faults, folds, faulted blocks, push-up structures and imbricate thrusts. On the other hand, the subtle tectonic perturbation of the fluvial landforms is made evident by different kinds of drainage anomalies (Howard 1967, DeBlieux 1949) such as deflected streams, asymmetric basins, zonal variations in drainage density, anomalous stream sinuosity and incision anomalies. The association of these geomorphologic features defines tectonically controlled drainage anomalies areas (DAA), which are characterized by indefinite or diffuse borders and lineal, trapezoidal or irregular design at surface. These elements are associated with subtle uplift, rotation, propagation or migration of structures.

An analysis of the distribution and the spatial relationship between the tectonically controlled topographic highs and the tectonically controlled drainage anomalies areas at these piedmont plains has made possible to elucidate the role of the drainage anomalies areas as a superficial expression of soft-linkage areas in fault systems.

A useful tool in order to determine slight tilting and ductile strain is given by a detailed study of drainage areas of anomalous behavior. The tectonically controlled topographic highs would be interpreted as isolated features without the consideration of subtle drainage anomalies between them. Furthermore, the set of tectonically controlled topographic highs linked by tectonically controlled drainage anomalies areas makes possible to clarify major regional structures like Quaternary deformation belts on their initial development stages, which exhibit mechanical interconnection.

At 32º SL a wide neotectonic soft-linkage deformation belt, the Yalguaraz belt, could be highlighted. This belt links the northwestern edge of the Precordillera Sur (Barreal block, El Naranjo range, Ansilta range, El Abra high) with minor tectonic blocks (Cucaracha range) of the Cordillera Frontal.

Lastly, the presence at the northwestern side of the Precordillera Sur of an anisotropic basement with Paleozoic and Mesozoic previous structures may favour the ductile linkage of Quaternary faults along wide deformation belts.

References

Cortes J, Yamin M & Pasini M (2005) La Precordillera Sur, Provincias de Mendoza y San Juan. Actas 16° Congreso Geologico Argentino Tomo 1 39:5-402

Cortés J & Cegarra M (2004) Plegamiento Cuaternario transpresivo en el piedemonte suroccidental de la Precordillera sanjuanina. Revista de la Asoción Geológica Argentina Serie D Publicación Especial 7: 68-75

Cortés J & Costa C (1993) La deformación cuaternaria pedemontana al norte de la pampa Yalguaraz, margen occidental de la Precordillera de San Juan y Mendoza. Actas del 12º Congreso Geológico Argerntino y 2º Congreso de Exploración de Hidrocarburos 3: 241-245

DeBlieux C (1949) Photogeology in Gulf Coast exploration. American Association of Petroleum Geologists Bulletin v 33: 1251-1259

Howard A (1967) Drainage analysis in geologic interpretation: a summation. American Association of Petroleum Geologists Bulletin, v 51: 2246-2259

Terrizzano C (2006a) Deformación transpresiva pleistocena en el piedemonte de la depresión de Barreal – Uspallata, Precordillera Sur, Argentina. Actas 11º Congreso Geológico Chileno: 465-468

Terrizzano C (2006b) Deformación cuaternaria en las Lomitas Negras, cinturón Barreal_Las Peñas, provincia de San Juan. Resúmenes de la 13º Reunión de Tectónica: 57

Terrizzano C, Cortés J, Fazzito S & Rapalini A (2008) Neotectonic transpressive zones in Precordillera Sur, Central Andes of Argentina: A structural and geophysical investigation. In press: Journal Neues Jahrbuch für Geologie und Paläontologie

---

Chemical, petrologic and experimental constraints on the pre-eruptive conditions of Lascar volcano, Central Andean magma systems

Torresi G 1, Botcharnikov RE 1, Holtz F 1, Banaszak M 2, Wörner G 2

1 Institut für Mineralogie Universität Hannover, Callinstr. 3, 30167 Hannover, Germany, g.torresi@mineralogie.uni-hannover.de

2 GZG, Abt. Geochemie, Goldschmidtstr.1, 37077 Göttingen, Germany

Lascar Volcano is a calc-alkaline stratovolcano located in the Central Volcanic Zone (CVZ), Northern Chile. The volcanic activity of Lascar started about 5 Ma ago and moved first eastwards and then westwards. Lascar represents the most active volcano of this area. Volcanic sequence has been divided into four main stages (43 to 26.5 ka for stage I, 26.5 ka for stage II, 22.3 to 9.3 ka for stage III and

7.1 to present for stage IV). The major rock types of Lascar are mainly porphyritic andesites to dacites with plagioclase as the dominant phenocryst. The activity of Lascar has been characterised by cyclic behaviour involving the growth and subsidence of lava domes, degassing of the magma, and vulcanian to plinian eruptive events culminated in the bigger eruption on 1993. Geochemical analyses combined with experimental simulations are used to discuss the role of mixing and fractionation during magma ascent and the pre-eruptive conditions in the magma chamber.

Hornblende-plagioclase and clinopyroxene-orthopyroxene thermometry, magnetite-ilmenite thermo-oxy-barometry and amphibole barometry, were applied to characterize the magmatic conditions of the most recent eruptions from stage IV (for details see Banaszak et al., this session). Hornblende-plagioclase thermometry as well as clinopyroxene-orthopyroxene pairs yielded a large and continuous temperature interval of crystallization from ~ 850 to 1010°C. Temperature and oxygen fugacity determined from magnetite-ilmenite pairs vary from 840 to 950 ºC at oxidizing conditions from 1.0 to 2.0 log units above NNO. The compositions of amphiboles provide estimates for pressures from 200 to 500 MPa for Lascar andesites. Geochemical data such as strontium isotopes ($^{87}Sr/^{86}Sr$) from Lascar volcanic sequence show clearly enriched values (0.7057-0.7066) for the last eruptive events (stage IV) in respect to other compositions from different stages. Also oxygen isotopes show the same enrichment trend (□ ^{18}O = 6.5–7.1) demonstrating increasing crustal contamination in the most recent lavas.

Additional constraints on the pre-eruptive conditions could be derived from melt inclusions in mineral phenocrysts of Lascar lavas, bombs and pyroclastics. Several samples have been investigated, showing that phenocrysts of plagioclase, ortho- and clinopyroxenes and also rare olivines contain entrapped and well-preserved melt inclusions. The dimensions of inclusions vary from less than 10 to more than 100 µm. For the measurements only the inclusion larger than 50 µm were selected. Plagioclase phenocrysts were analysed first, and melt inclusions reveal dacitic to rhyolitic compositions. The analysis of volatiles indicates the presence of chlorine, fluorine and sulphur but in relatively small concentrations. Further work is in progress to analyse concentrations of H_2O and CO_2 in the inclusions (in particular, in olivine).

An andesitic white pumice has been chosen as starting composition for the crystallization experiments. This sample is representative of the last stage (i.e. stage IV) eruptions, with magma composition containing ~ 58 wt% of SiO_2 and ~ 5 wt% of MgO. The major phases present in this sample are plagioclase, two pyroxenes and amphibole. Accessory phases are also oxides, sulphides and rare olivine. Plagioclase has a calcic composition (An_{30-70}), while clinopyroxenes are dominated by augite composition. First experimental results will be presented.

Classification of Andean Permafrost, an attempt

Trombotto Liaudat D

IANIGLA, Mendoza, Argentina

This is an attempt to present a classification of permafrost types with the help of different examples and study cases of mountain permafrost in the Andes, which may be applied for permafrost mapping and which would express periglacial geomorphology as well as physical cryogenic characteristics of mountain permafrost. This classification is different from the classification presently applied to Arctic regions. According to the MAAT map the area with Andean permafrost in South America represents an important area which is considered in the present work. It constitutes an enormous water supply and is of crucial hydrological and economic importance for human settlements near the Andes.

At first glance mountain permafrost may be divided into two large environments, one with permafrost *in situ* and the other associated with the movement of frozen cryosediments and ice, known as creeping phenomena, and the landforms identified as rockglaciers (glaciares de escombros or litoglaciares as regional names). Both environments are completely different one from the other and the rockglaciers, in form of *creeping permafrost*, may reach down to heights in the mountaineous systems where permafrost in a paraperiglacial environment does not exist anymore. A detailed analysis of mountain permafrost however, allows to identify particular and exceptional situations which are different from the ones mentioned before. The occurrence of Andean permafrost up to the high frozen summits and following the altitudinal curves is of „discontinuous" character and is optimized in a permafrost type called "„*quasi-continuous permafrost*" by some authors. This kind of permafrost is influenced mainly by topography, geomorphology, exposition, petrology and surface energy balance, and is the most reliable and outstanding representative of frozen ground to be mapped. Scarce meteorological data, poor topographical maps and the inaccessability of some areas by land or air complicate the task. Nevertheless, applying classical geomorphological and geophysical methods, modeling of ground thermal state as well as direct observations through superficial drillings and temperature measurings pilot areas may be selected to identify the permafrost types that will be characterized.

Certain thermal soil conditions also cause zonal or azonal permafrost in a type considered to be insular. On the other hand the absence of visible ice (or soils with very little ice content) reminds of a variety of *dry permafrost* which also appears in certain sites with quasi-continuous permafrost. On the other hand, looking at the „rockglacier or *creeping permafrost pattern*" of the Central Andes of Mendoza, it becomes obvious that the area is one of the most significant areas of this kind on our planet. In this last case *degraded permafrost* may also be identified through the activation and enlargement of ancient thermokarst forms. These landforms do not only create a characteristic landscape, they are also most significant for the climatic and palaeoclimatic history of the region.

Isotopic variations throughout Colima Volcanic Complex, México.

Valdez-Moreno G 1, Schaaf P 2, Kusakabe, M 3

1 Unidad Académica de Ciencias de la Tierra, Universidad Autónoma de Guerrero, Taxco El Viejo Guerrero, Mexico. valdezm@servidor.unam.mx

2 Laboratorio Universitario de Geoquímica Isotópica (LUGIS), Instituto de Geofísica and Instituto de Geología, UNAM, México, D.F., Mexico. pschaaf@geofisica.unam.mx

3 Institute for Study of the Earth´s Interior (ISEI), Okayama University, Misasa, Tottori-ken 682-0193, Japan kusakabe@misasa.okayama-u.ac.jp

Colima Volcanic Complex (CVC), located in the western Trans-Mexican Volcanic Belt (TMVB) forms a group of three stratovolcanoes, with ages that shows a migration from North (older; Cántaro) to South (younger; still active Colima volcano). Additionally a group of scoria cones is associated to the complex. Volcanic products are dominantly andesitic to dacitic in the stratacones, and alkaline basalts in the scoria cones. Our study provides new geochemical and Sr-Nd-Pb-O isotopic data covering the N-S transect to investigate latitudal variations within the complex. Results show that CVC magmas display strong subduction signatures (positive peaks of Ba, K, Pb, and Sr together with negative anomalies of Nb and Ti). Variations are as follow: Cantaro: La/Yb: 10.7-18.1, 87Sr/86Sr: 0.7036-0.7058, eNd: +2.7-4.7; N. Colima: La/Yb: 6.3-10.5, 87Sr/86Sr: 0.7034-0.7035, eNd: +4.9-+5.9; Colima volcano: La/Yb: 5.5-9.1, 87Sr/86Sr: 0.7035-0.7036, eNd: +5.3 -+7; Alkaline cones: La/Yb: 16.2-31.4. 87Sr/86Sr: 0.7036- 0.7038, eNd: +3.1 + 5.9. Considerable variations in La/Yb and Nd isotopes are observed for Cantaro and alkaline cones with respect to Colima volcano. Such variations can be interpreted as the result of mantle heterogeneities or different contributions of the subducted Cocos and Rivera plates beneath the CVC. Lead isotopes are not showing a significant variation within the CVC and can be explained by a contribution of sediments derived from the Cocos and Rivera slabs. Oxygen isotopes were performed for Colima volcano only and show variations between (delta 18 O) 5.7 - 6.8. These variations emphasize that crustal assimilation was not an important magmatic process involved in magma generation of CVC volcanic products.

Geochemical constrains on the Late Triassic plutonism along the Chilean margin: new data from the Carrizal Bajo Intrusive Complex and tectonic implications

Vásquez P, Creixell C, Arévalo C

SERNAGEOMIN Servicio Nacional de geología y Minería, Chile, pvasquez@sernageomin.cl

The Chilean Pacific continental border is a long-lived active margin since the Late Carboniferous (>300 Ma). Two tectonomagmatic stages have been documented at this margin during this time, namely the Gondwana (Carboniferous-Late Triassic?) and the Andean (Late Triassic-Recent) orogenies. During the transition between these two stages, granitoids and related mafic intrusives were emplaced in todays Chilean Coastal Cordillera.

At the 210 - 197 Ma, in south central Chile it has been identified a magmatic pulse represented mainly by small plutons like La Estrella Granite (arfvedsonite granite, 34°15'S) and the Cobquecura Pluton (fayalite-bearing granitoids, 36°S) (Vásquez et al., in review). This last pluton displays a bimodal association including mingling structures (Vásquez and Franz, 2008). These intrusions show geochemical and mineralogical characteristics that suggest subduction related extension, particularly the coexistence of Nb-Ta anomalies (typical of subduction) with anorogenic signatures (Vásquez et al., in review).

The Limarí Plutonic Complex occurs at the Coastal Cordillera (30°40'-31°45'S). This complex is also composed of bimodal association with leucogranites, gabbros and mingling structures (Gana, 1991, Parada et al., 1999). Whole rock Rb/Sr ages range between 200 and 220 Ma (Irwin et al., 1988). The isotopic signature in the Limarí complex as well as in the late Triassic intrusive suites in south central Chile is mantle-related with variable degree of assimilation of crustal melts.

The Late Triassic Carrizal Bajo Intrusive Complex (CBIC; Welkner and Arévalo, 2002) crops out along the Coastal Cordillera of northern Chile (27°45'-28°20'S). It intrudes metasediments from the Devonian-Carboniferous Chañaral Epimetamorphic Complex. The CBIC is composed of four flat-lying plutonic layers, of alternating granitic and dioritic compositions. The interface between these layers is sharp and in most cases are intrusion breccias exhibiting mingling structures (Arévalo and Welkner, 2008). Single zircon U-Pb ages obtained in this complex range between 206 and 207 Ma (Cruden et al., 2004). These ages and the mingling structures show that the plutonic layers were coeval.

New geochemical data from CBIC show high HFSE (High Field Strength Elements) contents, without Nb anomalies. The mafic rocks display mantelic affinities. The trace element patterns from the CBIC are parallel and suggest a common genesis for both felsic and mafic terms. The occurrence of mingling structures is a common feature in most of the mentioned complexes here. It is advanced in this contribution that the coexistence of felsic and mafic magmas in the Late Triassic favoured the generation at of these structures at a large scale, which are not seen in another geological periods in the Chilean Andes.

The mantle affinities in the Late Triassic subduction-related magmatism are more important than in the previous crustal derived Late Paleozoic magmatism (Parada et al. 1999, Vásquez et al., in review). However, the geological and geochemical characteristics from the CBIC like the large magma volume, the absence of Nb anomalies in comparison to those of the late Triassic intrusive suites in south-central Chile suggest that the Late Triassic extension had a major development toward the north. This seems to be confirmed by the presence of well developed Upper Triassic depocenters described as extensional basins in the Copiapó-Chañaral northern Chile Precordillera (Charrier, 1979; Mpodozis and Cornejo, 1997; Iriarte, 1997).

References

Arévalo C.; Welkner D. (2008). Geología del Área Carrizal Bajo-Chacritas, Región de Atacama. Servicio Nacional de Geología y Minería, Carta Geológica de Chile, Serie Geología Básica 111: 67 p.

Charrier R. (1979). El Triásico en Chile y regiones adyacentes de Argentina: una reconstrucción paleogeográfica y paleoclimática. Comunicaciones 26: 1-37.

Cruden A. R., Arevalo C., Davis D. D., Grocott J (2004) American Geophysical Union, Fall Meeting.

Gana P. (1991). Magmatismo bimodal del Triásico superior-Jurásico inferior en la Cordillera de la Costa, provincias de Elqui y Limarí. Rev. Geol. Chil. 18: 55-68.

Iriarte S. (1997). Análisis de facies volcánicas y estructuras contemporáneas durante el Triásico Superior en la Precordillera de Copiapó (27º-28º Lat. S.): relaciones con la sedimentología y evolución paleogreográfica. VIII Congreso Geológico Chileno: 504-508. Antofagasta.

Irwin J, García C, Hervé F, Brook M (1988) Geology of a part of a long-lived dynamic plate margin: the Coastal Cordillera of north-central Chile, latitude 30º51'–31ºS. Can J Earth Sci 25:603–624

Mpodozis C., Cornejo P. (1997). El rift Triásico de Sierra Exploradora, Cordillera de Domeyko (25º-26º S): asociaciones de facies y recontrucción tectónica. VIII Congreso Geológico Chileno: 550-554. Antofagasta

Parada M.A., Nyström J., Levi B. (1999). Multiple sources for the Coastal Batholith of central Chile (31-34°S): geochemical and Sr-Nd isotopic evidence and tectonic implications. Lithos 46: 505-521.

Vásquez P., Franz G. (2008): The Cobquecura Pluton (Triassic, Central Chile), an example of a fayalite granite bearing A-Type granitoid massif at a continental margin. Tectonophysics, 459: 66-84.

Vásquez P., Franz G., Glodny J., Frei D., Romer R. (in review): Early Mesozoic granitoids of the Cordillera de la Costa (34-37°S), Chile: Constraints of the onset of Andean Orogeny. J. Geol.

Welkner D., Arévalo C. (2002). The Carrizal Bajo Breccias: indications of contemporaneity between two end member magmas in a Late Triassic Extensional setting, northern Chile. *In* International Symposium on Andean Geodynamic, 5: 697-700, IRD éditions. Paris

Mineralogy and Geochemistry of Upper Cretaceous Volcanic Ash-Layers of the NE Mexico: San Felipe Formation

Velasco-Tapia F, Chávez-Cabello G, Martínez-Limas NA, Gómez-Alejandro AG, Becerra- González C & Medina-Barrera F

Facultad de Ciencias de la Tierra, UANL. Linares NL, Mexico, velasco@fct.uanl.mx

Introduction: During the Mesozoic, greenhouse melting of polar ice caps combined with global tectonic processes resulted in eustatic highstands that flooded many continental regions with epeiric seas, significantly expanding the shallow coastal zone of the oceans. One of the best preserved records of a Cretaceous epeiric sea is the Western Interior Seaway (CWIS), a mid- to high latitude, meridional retroarc foreland basin that extended for approximately 5000 km from present day Arctic Canada to the Gulf of Mexico and connected the northern Boreal Sea with the circum-equatorial Thetys Sea (Kauffman, 1984). The CWIS was bounded on the west by the Sevier Orogenic Belt, which supplied most of its sedimentary fill and was responsible for a significant portion of its subsidence history. This subsidence, in combination with long-term eustatic rise, resulted in accumulation of over 5 km of sediment in the CWIS spanning Albian through Maastrichtian time (Kauffman and Caldwell, 1993). These deposits represent mixing of two main sedimentary sources: (a) Sevier-derived siliciclastics and (b) pelagic-derived carbonate and organic matter. Fisher and Schminke (1984) established that the term "bentonite" has become widely used to refer to any thin, widespread clay bed that is of probable volcanic origin, regardless of dominant clay mineralogy. Altered volcanic ash-beds are abundant and widespread in upper Mesozoic and Tertiary strata from SW Canada to South central United States, along the CWIS (e.g., Elder, 1988; Cadrin et al., 1995; Collins, 1997; Nielsen et al., 2003; Foreman et al., 2008). These deposits have been related with the intense volcanic activity that accompanied the development of the Western Cordillera of North America 2 (Canada to Mexico) in Late Cretaceous and Tertiary time, although volcanism has also been reported in SE United States, Central America, and Caribbean zone (Cuba, Puerto Rico & Northern Colombia) during this period (Collins, 1997).

San Felipe Formation: The Sierra Madre Oriental (SMO) is a 2-3 km-thick Mesozoic-Cenozoic sedimentary belt distributed along the NE and central Mexico (Goldhammer, 1999; Chávez-Cabello et al., 2004). It is constituted by carbonate, siliciclastic and evaporitic rocks, deposited over a basement-complex that includes Precambrian methamorphic rocks, Paleozoic schist/sedimentary, and Upper Triassic-Lower Jurassic red-beds. SMO was affected by the Laramide orogeny, a Late Cretaceous to Paleocene (80-55 Ma) orogenic event given a fold-thrust belt that stretches nearly 1500 km from northern to southern Mexico. The objective of this study was to establish the mineralogical and geochemical features of the San Felipe Formation (Coniacian-Santonian), a lithologic unit included in the SMO. On the basis of this information, and considering an adequate paleogeographical-

geological framework, has been possible to establish a preliminary provenance model for these deposits.

San Felipe Formation was defined as a calcareous-clayey sequence, interbedded with several fine-grain green beds (limolite), changing to brown with alteration (Seibertz, 1986). Three detailed lithologic profiles were studied in Cerro Prieto (Linares, N.L.), Puerto Pastores (Galeana, N.L.), and Pedro Carrizales (Rayones, N.L.) localities. Limestone, shale, and limolite beds were collected from the contact with Agua Nueva Formation until the contact with Méndez Formation. Samples were studied via: (a) petrographic analysis, (b) X-ray diffraction (XRD), (c) electron microprobe (EM), and (d) geochemical analysis of major-elements by ICP-OES and trace-elements by ICP-MS. According with the matrix characteristics, limestone were classified as biomicrite or biosparite, whereas that they were considered as mudstone in function of the sediment percentage supported by the matrix. Sometimes, planctonic foraminifera (e.g., Globigerina and Globotruncana) were identified in these sediments. Shale is constituted by quartz, feldspar, and iron oxides microphenocrysts, embedded in a clayey matrix. Green limolite shows a fine matrix constituted by clay and vitreous particles with a needle shape. These beds also include quartz, K-feldspar, plagioclase, biotite, and zircon phenocrysts. XRD and EM analysis confirmed the presence of this mineralogy, accompanied by smectite (potassic montmorillonite) and chlorite. Mineralogical features and geochemical composition of limolithic sediments is comparable with those reported for CWIS altered volcanic-ash layers. According to major-element contents, San Felipe limolithic sediments were classified as shale, greywacke, arkose, and lithoarenite. Immobile trace-element diagrams revealed that green limolite beds were originated from a felsic volcanic source, although the chemistry of some rocks indicates an intermediate volcanic provenance. Geochemical maturity-indexes revealed that clastic rocks can be considered as immature first-cycle sediments. Several discrimination diagrams showed its association with a continental arc setting. A multivariate hierarchical cluster technique (Bratchell, 1989), considering immobile trace elements, was applied to limonitic samples from the Rayones profile. The resulting dendogram was interpreted to have classified the samples into three major groups, with statistically different geochemical compositions (labeled as lower, intermediate, and upper stratigraphic groups). These groups could be related to different volcanic sources or time-evolution in geochemical composition of the same sources. Late Cretaceous magmatic activity centers probably represent the emission sources for the San Felipe green limolite, especially those located in the North American and Mexican western coast.

References

Bratchell N (1989) Cluster analysis. Chem Intell. Lab Sys 6: 105-125.

Cadrin, AAJ, Kyser, TK, Caldwell, WGE, Longstaffe, FJ (1995) Isotopic and chemical compositions of bentonites as paleoenvironmental indicators of the

Cretaceous Western Interior Seaway. Palaeogeograph Palaeoclimat Palaeoecol 119: 301-320.

Chávez-Cabello G, Cossío-Torres T, Peterson-Rodríguez R (2004) Change of the maximum principal stress during the Laramide Orogeny in the Monterrey Salient, northeast Mexico. In *Orogenic curvature; integrating palomagnetic and structural analyses*, Sussman AJ, Weil AB (eds) Geological Society of America Special Paper 383: 145-160.

Collins JG (1997) Characteristics and origin of the Cedar Hill bentonite bed, Lower Austin Chalk, Dallas County Vicinity. M.Sc. thesis, University of Texas at Arlington, 102 p.

Elder WP (1988) Geometry of Upper Cretaceous bentonite beds: implications about volcanic source areas and paleowind patterns, western interior, United States. Geology 16: 835-838.

Fisher RV, Schminke H-U (1984) Pyroclastic rocks. Springer-Verlag, New York, 472 p.

Foreman BZ, Rogers RR, Deino, AL, Wirth KR, Thole JT (2008) Geochemical characterization of bentonite in the Two Medicine Formation (Campanian, Montana), including a new 40Ar/39Ar age. Cretaceous Res 29: 373-385.

Goldhammer RK (1999) Mesozoic sequence stratigraphy and paleogeographic evolution, Northeast Mexico. In *Sedimentary and Tectonic History of North-Central Mexico*, Bartolini C, Wilson JL, Lawton TF (eds) Geol Soc Am Spec Pap 340: 1-58.

Kauffman EG (1984) Paleobiogeography and evolutionary response dynamic in the Cretaceous Western Interior Seaway of North America. In *Jurassic-Cretaceous Biochronology and Paleogeography of North America*, Westermann GEG (ed) Geol Assoc Canada Spec Pap 27: 273-306.

Kauffman EG, Caldwell WGE (1993) The Western Interior Basin in space and time. In *Evolution of the Western Interior Basin,* Caldwell WGE, Kauffman EG (eds) Geol Assoc Canada Spec Pap 39: 1-30.

Nielsen KS, Schröder-Adams CJ, Leckie DA (2003) A new stratigraphic framework for the Upper Colorado Group (Cretaceous) in southern Alberta and southwestern Saskatchewan, Canada. Bull Can Petrol Geol 51: 304-346.

Seibertz E (1986) Paleogeography of the San Felipe Formation (MID- Cretaceous, NE Mexico) and facial effects upon the Inoceramids of the Turonian/Coniacian transition. Zbl Geol Paläont 9/10: 1171- 1181.

Aquifer transboundary Pantanal in Paraguay

Velasquez C

vcelso10@gmail.com, setipy@gmail.com

Summary: The present work must like objective present/display the geologic and hydrogeology characteristics of the Complex Aquifer the High Paraguay, (CAAP), which constitutes on a regional scale transboundary a single hydrogeology system that extends in part of Brazil, Bolivia and Paraguay. (CAAP). The River basin of the Paraguay Stop lodges to the Paraguayan pantanal ecosystem and its areas of influences. The same one has approximately 137,000 km^2 and it approximately represents 10% of the total of the River basin of the Paraguay Stop that includes part of Brazil, Bolivia and Paraguay and is located waters above of the Great River basin of the River of the Silver.



The geologic and hidrogeológicas characteristics

The approximately 18,000 CAAP includes km2. These water-bearing ones are constituted by alluvial, fluvial sediments, palustres and lacustrine of possible Tertiary age - Quaternary. In the Western region the variations of regional levels, are between the 2 to 10 M.s The thicknesses are not greater to 12 ms, although cases of layers with 40 could occur powers of a 50 M.s specifically, in the zones lagunares (hondonas regional).

Uses more frequent of the Water of the CAAP. In the Eastern region they conform Aquifers of importance with thicknesses of until approximately of 80 meters and their waters they are used in rural communities in the North of the country like potable water source . The CAAP is very vulnerable by their texture, lack of cementation and is it holds to direct charges of meteoric waters, contributions of the river Paraguay in his cyclical ascents and bajantes and other affluents and runoffs of smaller importance and the unloading is made through the operation of wells and process of evaporation in climate of high temperature.

Environmental context: To preserve the Aquifer one, taking care of mainly the zones of charges, including/understanding the fresh and salty water interaction and this one with the surroundings it will help to maintain the hydrogeology cycle of the fundamental water for the support of an ecosystem of global importance. In agreement to the first observations the main threats to this important and strategic resource are the entropic intervention more and more accelerated, the deforestation and it burns of forest and pastures that cause negative impacts to the biodiversity and the natives, the precious mineral operation waters above of the Paraguay river with the usual mercury use and the uncontrolled operation that the CAAP is put under. It will be of fundamental importance the involvement of the settlers from the beginning of any initiative in the area, in order to guarantee the commitment of the local society in the management of this valuable resource.

Conclusions: The shared underground water resource between the countries of Brazil, Bolivia and Paraguay, in the river basin of the Paraguay Stop is denominated Aquifer Pantanal in both first countries. In Paraguay it is known with the name of Water-bearing Complex the High Paraguay The Aquifer Pantanal denominated in this work Water-bearing complex the High Paraguay it comprises of a Aquifer System Pantanal. One of the aspects most important of the Complex Aquifer the High Paraguay is its fundamental importance in the pantanal ecosystem It will be necessary to look for to interrelate the existing information between the three countries for which it will be necessary to carry out integral and interdisciplinary studies.

Upper Jurassic-Lower Cretaceous Ammonoids of the Vaca Muerta Formation, Neuquén Basin, Argentina

Vennari VV

Depart. Ciencias Geológicas. Facultad de Ciencias Exactas y Naturales (FCEN), Univ. de Buenos Aires (UBA). Pab. 2 - Ciudad Universitaria (C1428EGA, Buenos Aires, Argentina, Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), vvennari@gl.fcen.uba.ar

Vaca Muerta Formation (Weaver, 1931) consist of an Upper Jurassic-Lower Cretaceous marine sedimentary succession of dark bituminous shales, marls and several types of bioclastic carbonates, reaching hundreds of meters at some localities. It is widely distributed over all the Neuquén Basin, which is located at the eastern side of the Andes of Argentina and central Chile, between 32º and 40ºS latitude. It has a more or less triangular shape and it has been nearly always limited to the NE by the Sierra Pintada Massif, to the SE by the Nordpatagonian Massif and to its western side by the Andean magmatic arc.

Vaca Muerta Formation is a very important unit, not only by its rich fosiliferous content but also by its petroleum source potential. It is also well known by its abundant ammonoid fauna which allowed the construction of a reasonable biozonation for the early Tithonian-late Valanginian interval (Leanza, A., 1945; Leanza, H. 1980, among other previous authors). Nevertheless, this scheme needs to be updated to achieve in the future a greater level of detail and accuracy, especially to improve the biostratigraphic resolution around the Jurassic-Cretaceous boundary. To accomplish that aim the ammonoid fauna of some localities of the Vaca Muerta Formation are studied together with the sedimentary context and their stratigraphic framework (Vennari et al., 2007; Vennari 2008; Kietzmann and Vennari, 2008).

One of the sections, 522 meters thick, was measured at the locality of Cerro Domuyo (36º41' S; 70º26' W), a region with difficult access in northern Neuquén Province in western central Argentina. At this place the sedimentites of the Vaca Muerta Formation conformably lie over the greenish sandstones of the Tordillo Formation (Kimmeridgian), while miocene volcaniclastic and piroclastic rocks cover them in turn. The section is characterized by the rhythmic alternation of dark shales and marls with microbial or concretional mudstones, laminated mudstones and/or wackestones, bioclastic wackestones, packstones and floatstones. Some event beds have been recognized as well, including sandy wackestones with HCS and sandstones facies associated with storm and turbidity currents deposits. The whole sedimentary succession has been interpreted as a carbonate-siliciclastic ramp dominated by outer ramp and basin facies (Kietzmann and Vennari, 2008).

In association with the abundant ammonite shells and aptychus spread all over the section, there were found too some belemnite rostra, bivalves (including pectinids, oysters and lucinids), disarticulated large bones and scales of undetermined vertebrates and also some wood fragments. The traditional ammonoid biozonation proposed by Leanza, H. (1980, 1981a, b) was followed to analyze particularly the ammonoid fauna found at this locality.

0-7 m: *Virgatosphinctes mendozanus* biozone, defined by Burckhardt (1900), is restricted, until now, to the lower Tithonian. Here includes specimens of *Choicensisphinctes choicensis sutilis* Leanza, H., *Choicensisphinctes choicensis* (?) (Burckhardt), *Pseudoinvoluticeras douvillei* Spath, *Pseudoinvoluticeras windhauseni* (?) (Weaver) and *Virgatosphinctes dorsoplanus* (Vischniakoff). This biozone extends over outer ramp facies where microbial mudstones and hardgrounds are quite frequent.

7-60 m: *Pseudolissoceras zitteli* biozone, also established by Burckhardt (1900), is considered equal to the upper portion of lower Tithonian and the lower part of middle Tithonian. It is represented here by many shells assigned to *Pseudolissoceras zitteli* (Burckhardt) and its related aptychus (*Laevilamellaptychus*). It is worth noting that on the same beds there were find some specimens of *Virgatosphinctes denseplicatus rotundus* Spath and, despite their bad preservation, probably also of *Virgatosphinctes andesensis* (Douville), both of them are traditionally considered to belong to the previous biozone. The *Pseudolissoceras zitteli* biozone is associated with anoxic to

disoxic basin facies and more oxygenated outer ramp facies.
60-67 m: *Aulacosphinctes proximus* biozone, although originally established by Burckhardt (1900) as *Aulacosphinctes colubrinoides* zone, was then redefined by other authors (e.g. Groeber, 1946). It is typically associated with the middle Tithonian. At Cerro Domuyo section, it includes specimens of *Aulacosphinctes proximus* (Steuer), *Aspidoceras andinum* Steuer, *Laevaptychus* (commonly found in association with Aspidoceratids) and *Odontoceras ellipsostomum* Steuer. This briefly extended biozone is found also related to outer ramp facies.
67-158 m: *Windhauseniceras internispinosum* biozone, differentiated by Weaver (1931), is mostly extended over the upper Tithonian and here is represented by laterally compacted specimens of *Windhauseniceras internispinosum* (Krantz) and some of *Corongoceras lotenoense* Spath. This biozone extends over outer ramp facies with and without microbial and concretional mudstones, and open basin facies.
158-220 m: *Corongoceras alternans* biozone, created by Leanza (1945) and considered equivalent to the lower part of the upper Tithonian. At this locality is represented by some fragmentary and bad preserved specimen of *Berriasella* sp. The *Corongoceras alternans* biozone is related at this section with outer and middle ramp facies.
220-281 m: *Substeueroceras koeneni* biozone, was defined by Gerth (1921) and was traditionally associated with the upper part of the upper Tithonian. The section studied includes a sandy wackestones/sandstones interval corresponding to the Huncal Member of the Vaca Muerta Formation (Leanza, H. et al. 2002). At this interval some specimens of *Pectinatites striolatus* (Steuer) and *Subteueroceras koeneni* (Steuer) were found; hence this subunit should be considered of an earlier age as previously proposed by its authors (Leanza, H. et al., 2002; 2003). 281-312 m: *Argentiniceras noduliferum* biozone established by Leanza, A. (1945) and equivalent to the lower Berriasian, has not yet been documented here. This interval is represented by open basin and slope facies.
312-522 m: *Spiticeras (Kilianiceras) damesi* biozone, differentiated by Gerth (1921), it is considered equivalent to the late Berriasian. Although not spiticeratids had been found in situ here, there were identified some specimens of *Thurmanniceras duraznense* (Gerth), *Cuyaniceras transgrediens* (Steuer), *Neocomites regularis* (Leanza) and *Neocosmoceras* sp. This last biozone recognized here corresponds to open basin and outer ramp facies, without microbial mudstones and with several concretional beds.

Therefore, at Cerro Domuyo locality the sedimentites of the Vaca Muerta Formation span from an early Tithonian to a late Berriasian age.

References

Burckhardt C (1900) Profils géologiques transversaux de la Cordillère Argentino-Chilienne. Museo de La Plata, Sección Geológica y Mineralógica, Anales 2: 1-136

Gerth E (1921) Fauna und Gliederung des Neokoms in der argentinischen Kordillere. Zb Mineralogie, Geologie und Paläontologie, 1921: 112–119 140–148

Groeber P (1946) Observaciones geológicas a lo largo del meridiano 70.1. Hoja Chos Malal. Revista de la Asociación Geológica Argentina 1: 177-208

Kietzmann DA, Vennari VV (2008) Facies, ambiente depositacional y estratigrafía de la Formación Vaca Muerta (Tithoniano inferior – Berriasiano superior) en el área del Cerro Domuyo, Neuquén. Actas 27º Congreso Geol Argentino, Jujuy 2: 773

Leanza AF (1945) Ammonites del Jurásico Superior y del Cretácico Inferior de la Sierra Azul, en la parte meridional de la provincia de Mendoza. Anales del Museo de La Plata NS 1: 1-99

Leanza AH (1980) The Lower and Middle Tithonian Ammonite Fauna from Cerro Lotena, Province of Neuquén, Argentina. Zitteliana 5: 3-49

Leanza HA (1981a) Faunas de ammonites del Jurásico superior y del Cretácico inferior de América del Sur, con especial consideración de la Argentina. In: Volkheimer W and Musacchio EA (Eds.), Cuencas sedimentarias del Jurásico y Cretácico de América del Sur. Comité Sudamericano del Jurásico y Cretácico, Buenos Aires 2: 559-597

Leanza HA (1981b) The Jurassic-Cretaceous boundary beds in West Central Argentina and theirammonite zones. N Jb Mineral Geol Paläontol 161: 62-92

Leanza HA, Repol D, Sruoga P and Salvarredy Aranguren M (2002) Nuevas unidades estratigráficas del Mesozoico y Cenozoico de La Comarca de Huncal, Provincia del Neuquén, Argentina. In: Cingolani CA., Cabaleri N, Linares E, López de Huchi MG, Ostera HA and Panarello HA (Eds.), Actas 15º Congreso Geológico Argentino, El Calafate 1: 619-624

Leanza HA, Hugo CA, Salvarredy Aranguren M (2003) El Miembro Huncal (Berriasiano inferior): un episodio turbidítico en la Formación Vaca Muerta, Cuenca Neuquina, Argentina. Rev Asociación Geol Argentina 58: 248-254

Vennari VV, Herrera Y, Aguirre-Urreta B (2007) La Formación Vaca Muerta en el flanco occidental de la Sierra Azul, Mendoza. Actas 3º Simp Argentino Jurásico: 80

Vennari VV (2008) Amonoideos de la Formación Vaca Muerta en el Arroyo del Yeso, Sierra Azul, Provincia de Mendoza. Final Paleontology Degree Research unpublished, Facultad de Ciencias Exactas y Naturales, Univ. Buenos Aires: 120 pp.

Weaver C (1931) Paleontology of the Jurassic and Cretaceous of West Central Argentina. Memoirs of the University of Washington 1: 1-496

Petrogenesis of gabbros from the Jilotlan pluton, Jalisco, Mexico.

Villanueva Lascurain D, Schaaf P 2, Solís Pichardo G 1, Hernández Treviño T 2, Salazar Juárez J 1, Corona Chávez P 3

1 Universidad Nacional Autónoma de México, Instituto de Geología. Ciudad Universitaria, México D.F, México.

2 Universidad Nacional Autónoma de México, Instituto de Geofísica. Ciudad Universitaria México D.F, México.

3 Universidad Michoacana de San Nicolás de Hidalgo, Instituto de Investigaciones Metalúrgicas, Edificio U, Ciudad Universitaria Morelia Michoacán, México.

The Guerrero composite terrane is the largest tectonostratigraphic terrane in Mexico and is composed by a sequence of submarine and subaereal volcanic and sedimentary rocks ranging in age from upper Jurassic to mid-upper Cretaceous. There are various hypothesis on its origin which are still matter of debate. Some support the idea of an autochthonous terrane build on a continental basement, others favor an allochthonous, far travelled arc that was accreted to the continent. A peripherial arc scenario developed more or less close to the continent prior to accretion was also proposed.

The Jilotlan batholith is part of the Mesozoic-Cenozoic magmatic arc assemblage of the central Guerrero terrane. It is located in the southern part of the Jalisco state and is part of the Cordilleran plutonic belt along the southern pacific margin of Mexico, which were uplifted prior to the margin truncation during de Paleogene.

A geologic map of the study area, petrography, geochemical and isotopic data of the gabbros from the Jilotlan pluton are presented here to explain igneous petrogenesis and paleotectonic environments.

In the central part of the study area the rocks are composed of gabbros (≈ 115 Ma by 40Ar*/39Ar in hornblende) which are intruded by a suite of more felsic plagioclase rich rocks that range from diorite to granite (≈ 70 Ma average). The whole plutonic assemblage intrudes volcano-sedimentary rocks of the Tecalitlan Formation (≈130 Ma). There are textural variations in the gabbros, the granites and the mafic and felsic dikes associated with the pluton.

Both, gabbros and more felsic rocks, have isotopic compositions with initial □Nd between +3 to +7 and initial 87Sr/86Sr from 0.7031 to 0.7038, with the gabbros as most primitive unit. Additionally all rocks display relatively flat REE patterns with slight enrichment in LREE with respect to HREE and multi-elemental patterns comparable to oceanic island arc rocks.

The geochronological data from the Jilotlan batholith emphasize the presence of two plutonic episodes separated by a ≈ 45 Ma hiatus. Field evidence favors in situ intrusion instead of accretion. Together with the Manzanillo batholith, the Jilotlan rocks show the most primitive geochemical and isotopic features in comparison to all other plutons in the Guerrero terrane, and are even less evolved than most volcanic rocks of the Trans Mexican Volcanic Belt.

Mediciones de gradiente de campo magnético en un Campo de Experimentación Geofísica en la Facultad de Ciencias de la Tierra, UANL, México

Villarreal-Uribe AL, Méndez-Delgado S, Constante-Galván H, Garza-Rocha D

Facultad de Ciencias de la Tierra, Universidad Autónoma de Nuevo León, México alvu_87@hotmail.com

La interpretación de datos geofísicos generalmente se realiza a través del modelado o la inversión de datos. En el modelado de datos se dan por conocidos los parámetros del modelo y se calcula la respuesta que se produciría ante un fenómeno físico (magnético, por ejemplo). Generalmente, dichos datos (sintéticos) son utilizados como información para probar algoritmos numéricos de inversión de datos, donde a través de ellos se busca un modelo que ajuste a dichos datos. Otra manera de probar tanto algoritmos de modelado como de inversión de datos es recurrir al modelado físico por medio de campos de experimentación, en los cuales se tengan cuerpos (de diversas geometrías) bajo la superficie terrestre en condiciones controladas.

En el año 2006 se realizó la adecuación de un campo de experimentación geofísica en la Facultad de Ciencias de la Tierra de la UANL, campus Linares, con dos finalidades: la primera académica; y la segunda de investigación (Constante Galván, 2008). El campo de experimentación geofísica consiste de una superficie de 400 metros cuadrados, bajo la cual fueron ocultados objetos diversos a varias profundidades. Entre los cuerpos enterrados se tienen: a) dos tanques de plástico con capacidad de 200 litros, uno de ellos lleno con agua y hielo seco, y el otro vacío; b) un tanque de fierro lleno de objetos de metal; c) dos láminas metálicas. También se enterraron tubos de PVC por donde se pretende hacer circular o almacenar diversos líquidos. La intensión del campo de experimentación es realizar pruebas para modelado de estructuras 2-D, 3-D y placas inclinadas. Según los tipos de cuerpos sepultados, se pueden utilizar los métodos magnetométricos, gravimétricos y geoeléctricos para descubrir su posición.

En este trabajo se muestran los resultados de las anomalías obtenidas por los métodos a) magnetométrico, b) electromagnético en el límite resistivo y c) por sondeos eléctricos verticales. En el método magnetométrico se realizaron mediciones de gradiente de campo magnético en perfiles que pasan sobre o cerca de los cuerpos metálicos (tanque y láminas). En el caso electromagnético se realizaron mediciones de conductividad aparente con el equipo EM 34-3 de Geonics, Ltd., en cuatro perfiles que cruzan sobre los cuerpos enterrados. Las mediciones se realizaron en las modalidades de dipolo magnético vertical y dipolo magnético horizontal con separaciones de 10 m entre dipolos. Las mediciones de resistividad de realizaron con el equipo SuperSting R1/IP, en la modalidad de sondeos tipo Schlumberger. En los tres casos se muestra que los cuerpos conductores (metálicos) son fácilmente detectados.

Referencias

Constante Galván H (2008) Detección de cuerpos someros con el equipo EM34-3 en el Campo de Pruebas Geofísicas de la Facultad de Ciencias de la Tierra. Tesis de Licenciatura, UANL. Facultad de Ciencias de la Tierra; Linares NL, México. 84 p.

Geochemical evolution of arc magmatism since Late Cretaceous of the Central American land-bridge

Wegner W 1, Wörner G 1, Harmon RS 2,3, Jicha B 4

1 GZG, Universität Göttingen, Germany
2 USARL Army Research Office
3 Department of Marine, Earth, and Atmospheric Sciences, N. Carolina State University
4 Department of Geology & Geophysics, University of Wisconsin, Madison

Major- and trace element geochemistry on 310 samples, 40 ^{40}Ar/^{39}Ar dates and ^{143}Nd/^{144}Nd, ^{87}Sr/^{86}Sr, ^{206}Pb/^{204}Pb, ^{207}Pb/^{204}Pb, and ^{208}Pb/^{204}Pb as well as d^{18}O isotope data from the Cordillera de Panama and the Peninsulas of Sona and Azuero, document the magmatic evolution and oceanic plate interactions over the last 100 Ma in western Panama.

A first phase of magmatism formed the oceanic basement of the Caribbean Large Igneous Plateau (CLIP). These Basalts were erupted from 95 to 69 Ma (Hoernle et al. 2004). Flat trace element patterns are – apart from some alteration effects, shown by some fluid mobile elements (Ba, K, Pb, Sr) - characteristic for the intraplate Galapagos plume (head-) source. Younger accreted terranes with enriched patterns of an intraplate mantle source were amalgamated to the Chortis block between 70 and 20 Ma (CLIP-OIB). Nd and Pb isotopes from these CLIP-OIBs also argue for an origin from the Galapagos hot spot (Hoernle et al. 2002).

The second major phase partly overlaps the first phase in time. Their arc trace element patterns (depletion in Nb and Ta plus enrichment of the fluid mobile elements such as Ba, K, Pb, and Sr) indicate the initiation of subduction at 71 to 69 Ma (CLIP-ARC) in the region. Apart from the (Large Ion Lithophile Elements) LILE-enriched arc signature, these "CLIP-ARC" magmas show (High Field Strength Elements) HFSE-trace element patterns very similar to the CLIP basement rocks. This implies the involvement of the pre-existing CLIP mantle source in magma generation. The CLIP-ARC thus displays the transition from intraplate to arc style magmatism. The "EARLY-ARC "comprises two major pulses from 68-60 Ma (Chagres Igneous Complex and Bayano area) and 50 to 40 Ma from the length of the Cordillera de Panama. It produced mainly depleted low K tholeiites and andesites, which, however, have larger variations in Nb, Ta and flat trace element patterns for the heavy rare earth elements (HREE), implying that mantle

source region at this time was partly depleted, heterogeneous and highly variable in incompatible elements prior to fluid enrichment. Residues of the old CLIP source may still be involved in these magmas but more depleted and more enriched sources are recorded as well. Therefore the whole EARLY-ARC source region is extreme inhomogeneous and composed of many different mantle components in all forming a new mantle source. Nd isotopes (≥0.512636) of EARLY-ARC samples are among the lowest in this region. Nd-, Sr- and Pb- isotopes in some EARLY-ARC rocks shows these as a distinct group with a mantle source that is not documented in older or later magmas.

The third phase of the "YOUNGER-ARC" (19-5 Ma) started after a significant magmatic gap of about 20 Ma. Basalts to dacites form discrete volcanic centers across the Cordillera de Panama with progressive enrichment from varied tholeiites to more uniform medium-K arc character. These come from a homogeneous and matured source as Nb and Ta depletion is more uniform, only few samples show depleted patterns comparable to the EARLY-ARC. Nd-, Sr- and Pb-isotopes are similar to the present Central American Arc (CENTAM). The cessation of the YOUNGER-ARC is related to the ridge- trench collision between the Cocos Ridge (in southern Costa Rica) and Central America.

The youngest phase consists of isolated adakitic centers along the Cordillera de Panama (<2 Ma). Adakites with depleted HREE patterns are diagnostic of residual garnet in the source. These adakites form the most coherent group. Their Nd-, Sr-, and Pb-isotopes follow the Galapagos Hot Spot trend indicating a high U/Pb mantle (HIMU) source component. Adakites are "heavy" in terms of $d^{18}O$ and in combination with the other isotopes, this is consistent with a seawater altered oceanic basalt source and melting of the leading edge of the Cocos Ridge and CLIP basement at the margins of a slab window.

Initiation of arc magmatism at 71 Ma coincides with the cessation of Galapagos plateau-formation, suggesting a causal link. The transition from intraplate CLIP to arc magmatism occurred relatively fast (3 Ma) and partly introduces a new enriched mantle source. Transition between EARLY- and YOUNGER-ARC (40 to 20 Ma) involves a change to more homogeneous intermediate composition. This indicates mixing and homogenisation of sub-arc magma sources with time and/or the replacement of the mantle wedge by a homogeneous, relatively undeleted asthenospheric mantle. The break-up of the Farallon plate at this time (~ 25 Ma) may trigger these changes. The newly established Cocos-Nazca spreading center leads to change in mantle movement, by upwelling below the new ridge. The plate movement direction changed (between 22.7 and 19.5 Ma) from mainly westward for the Farallon plate to northwest for the Cocos plate and southwest for the Nazca plate (Barckhausen et al. 2008). The collision of the Cocos ridge with the Central American trench resulted in the cessation of arc magmatisim in that region at ~ 5 Ma. Adakite volcanism (< 2 Ma) started after a gap of 3-5 Ma enabled by the formation of a slab window. Pb isotopes favour melting of the leading edge of the Cocos Ridge and/or CLIP basement as magma source.

References

Barckhausen U, Ranero CR, Cande SC, Engels M, Weinrebe W (2008) Birth of an intraoceanic spreading center. Geology 36: 767-770

Hoernle K, vd Bogaard P, Werner R, Lissinna B, Hauff F, Alvarado G, Garbe-Schoenberg D (2002) Missing history (16-71 Ma) of the Galapagos hotspot; implications for the tectonic and biological evolution of the Americas. Geology 30: 795-798

Hoernle K, Hauff F, vad Bogaard P (2004) 70 m.y. history (139-69 Ma) for the Caribbean large igneous province. Geology 32: 697-700

Tectonics, fluid flow and slope stability of the central Chilean subduction zone revealed with multibeam bathymetry and deep-tow side-scan sonar surveys

Weinrebe W 1, Klaucke I 1, Voelker D 1, Bialas J 1, Behrmann J 1, Ranero CR 2, Diaz Naveas J 3, Geersen J 1

1 Collaborative Research Center (SFB) 574 at the IFM-GEOMAR, Germany, wweinrebe@ifm-geomar.de

2 Institució Catalana de Recerca i Estudis Avancats (ICREA) Barcelona, Spain

3 Escuela de Ciencias del Mar, Universidad Catolica de Valparaiso, Chile

The convergent continental margin off Chile spans more than 3500 km providing various segments with different tectonic characteristics. Hence, it is an ideal area to study the interplay between tectonic, mass wasting and fluid flow processes at subduction zones. The northern part is clearly dominated by subduction erosion. The central part around 33°S is controlled by the subduction of the Juan Fernandez Ridge which changes the subduction style substantially. The area south of 37°S is predominantly accretionary.

Multibeam bathymetry provides a detailed map of the continental margin morphology, which displays tectonic processes, fluid flow and mass wasting structures. Large areas of the Chilean continental margin have been mapped bathymetrically in recent years by cruises with Chilean, German, and French vessels. A survey with British RRS James Cook in March 2008 completed bathymetric coverage in the central area between 37°S and 33°S, a key area for the understanding of different subduction styles, as it is characterized by the transition from subduction erosion to subduction accretion. Generally, the morphology of the continental slope in the surveyed area displays three different regions: The lower slope typically displays a rugged terrain, including collapse and mass wasting structures, whereas the middle slope is characterized by a series of smooth terraces probably representing mid-slope basins. Some small mound-like structures characterized by high-reflectivity in

the backscatter signal were mapped in the mid-slope area. A deep-tow side-scan sonar survey revealed the patchy appearance of the mounds typical for carbonates indicating fluid venting. The transition from the lower to the middle slope occurs across a roughly margin-parallel 150-km-long distinct lineament of alternating narrow highs and troughs suggesting strike-slip deformation. Their sharp relief and the transition from a rugged to a smooth morphology across them suggest that faulting is currently active. Across a moderate change in slope dip, the middle slope grades into the upper slope which displays a smooth morphology and gentle dips. The entire slope structure is cut by several large canyons that zigzag from near the coast to the trench. The canyons head is typically located at the mouth of the largest rivers in the area and possibly transport most of the sediment reaching the trench.

Water Resources in the Future Climate Change Scenario: Development of an Integrated Management Concept for Water Supply in the Federal District of Brasília – DF (Central Brazil)

Weiß H 1, Neder KD 2, Walde DH 3, Hirsch M 1, Roeser PA, Lohe C 1, Makeschin F 4

1 Helmholtz-Zentrum für Umweltforschung GmbH – UFZ, Germany holger.weiss@ufz.de
2 Companhia de Saneamento Ambiental do Distrito Federal – CAESB, Brasil
3 Instituto de Geociências da Universidade de Brasília – UnB, Brasil
4 Bodenkunde und Standortlehre Technische Universität Dresden, Germany

Project Goals: In the context of a joint research and development project (AGUA DF) between German and Brazilian partners, an integrated management concept is expected to be developed, in order to guarantee, both in terms of quantity and quality, the safe supply of water to the Federal District of Brazil and its surrounding urban areas, including adequate wastewater treatment and disposal.

This concept has to take into account the expected climate changes in the near future (e.g. longer dry periods and/or concentration of high precipitation in shorter periods), the fast population growth, and the trends of social and economical development and its impacts on urban areas expansion in Federal District Brasilia, with special attention to catchments with potential to be used as water supply sources, as water will get limited and demand will be increasing continuously.

Brasilia, as the capital of Brazil, and being located in the central region of the country, has got a key position for joint R&D activities between Germany and Brazil. Scientific results and technical approaches developed in the scope of this project can be extended to other region with similar characteristics, as well as promote the development of new models in different regions.

The project will also aim for a sustainable management concept, which considers and balances population versus water resources. In this authorities and NGO will be invited to take part into capability building measures.

The building of this joint project allows the German researchers, through the Brazilian partners, to introduce and adapt to the Brazilian reality some German innovative technology and materials in the field of water supply and sanitation systems integrated within the energy-saving and raw material conversion management concept.

In the climate change field, German and Brazilian research cooperation has to be built parallel to the main project. This parallel project aims to develop regional climate models for Brazilian central area and to simulate extreme climate change scenarios and their consequences in the region and in the water availability.

The Federal District: Present Water Supply and Wastewater Disposal

The urban region Brasilia developed in the last 50 years and has already approximately 2.5 millions in habitants. The problems of the competitive water use already existing are additionally strengthened by different factors:

- Development of the agricultural areas predominantly using irrigation methods in the Federal District at expense of the savannah (Cerrado) removal.
- Increasing of contamination of surface waters, soils and groundwater.
- Erosion problems in the catchments areas with consequent sediment filling of the reservoirs.
- Governmental programs which promote the cultivation of plants for the production of bio-fuels.
- Development of dams for hydro power generation.

In this scenario, CAESB, without taking into account the impact of the probable climate changes, predicts shortage of drinking water from 2010 for several parts of the Federal District, especially in the dry season. According to data, the average daily water household consumption in the Federal District is about 200 l. At high income residential areas it rises up to 400 l/c/d, and in poorer outlying districts it goes down to 100 l/c/d. A part of the water distribution network must be renewed, considering that figures show water losses in the order of up to 30% (annual basis).

Groundwater is seldom used by CAESB in its main water supply network, but as private wells is the exclusive water source of private horizontal settlements (Condominiums). In order to guarantee the future water supply, CAESB is planning the establishment of new water production systems.

Start Points: More considerations will require further assessment; however, the following project first outlines can be pointed out *Research Points:*

1. Survey and analysis of the present water supply condition in the Federal District, including:
   - Regional water balance and water quality, including surface and ground water.

- Surface and ground water monitoring (quality and quantity).
- Detailed hydrological cycle studies including infiltration behaviour in different soils and transpiration from the various cultures;
- Impact of human, agricultural and industrial occupation inside the water basins.
- evaluation of soils, groundwater and surface water pollution by agrochemicals, sewage, pharmaceuticals, nutrients, etc.

2. Development of models for the individual parts from the actual state analysis of the single projects on common database in GIS.
3. Integration of the developed regional climate models and scenario models with minimum and maximum precipitation and temperature variation.
4. Proposal of changes in current water resources management policy aiming to sustainable development and water resources use (e.g. land use, town development, cultivation of useful plants with smaller water requirement etc.).
5. Local, regional and supra-regional evaluation and examination.
6. Dissemination of the obtained results to areas with comparable climatic changes.
7. Development of decision support systems to subsidize stakeholder economical and political decisions.

Field activities

- Initial geophysical investigation campaign to assess aquifer vulnerability and impact of contaminant plumes from landfills on groundwater, groundwater recharge areas and potential drinking water sources.
- A first field campaign using surface geoelectrical investigation methods (resistivity measurements) yielded high resolution results for the determination of aquifer architecture, depth of phreatic surface and zones of preferential infiltration.
- The measurements also indicated differences in groundwater conductivity which could be correlated to seepage from a municipal landfill site.
- Currently the method is optimized and extended to full 3-D mapping of aquifer properties such as storage capacity for artificial recharge and vulnerability as well as the the delineation of groundwater protection zones around watersheds used for drinking water supply.

Cooperation Partners

Brazilian Partners: On the Brazilian side the CAESB work together with the Geoscience and Engineering Faculties of the University of Brasilia. For several years, a formal cooperation agreement between CAESB and UnB on water research and sanitary engineering in the region of Brasilia is already available, and numerous scientific works were developed. Related participating institutions are INMET (Instituto Nacional de Meteorologia), Novacap (Companhia Urbanizadora da Nova Capital do Brasil) and EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária).

German Partners

Considering the German cooperation partners the following is suggested: Helmholtz Center for Environmental Research (UFZ) Leipzig and the Technical University of Dresden (TU Dresden) as coordinating cooperation partner for the joint project. Related participating institutions are KIT (Karlsruhe Institute of Technology), the Universität der Bundeswehr – München and the water supply company Sachsenwasser, Leipzig.

Does Chilenia exist? Evidence from the evolution of collisional and coastal accretionary systems between the latitudes 30°S and 35°S

Willner AP 1,2, Massonne H-J 2, Gerdes A 3 , Hervé F 4, Sudo M 5, Thomson S 6

1 Inst. Geologie, Mineralogie, Geophysik, Ruhr-Universität Bochum, Germanyy ane.willner@rub.de
2 Institut für Mineralogie und Kristallchemie, Universität Stuttgart, Germany
3 Institut für Geowissenschaften, Mineralogie, J.W.Goethe Universität Frankfurt, Germany
4 Departamento de Geología, Universidad de Chile, Santiago de Chile, Chile
5 Institut für Geowissenschaften, Universität Potsdam, Germany
6 Department of Geology and Geophysics, Yale University, New Haven, CT, USA

Within the basement close to the western continental margin of South America between the latitudes 30°S and 35°S the occurrence of a separate microplate, accreted to South America in Late Palaeozoic times, has been proposed by Ramos et al. (1984). These authors called the microplate/terrane Chilenia. However, it is not exposed at the surface because of the extensive cover by younger sediments and volcanics. Evidence for the existence of Chilenia can be derived by unravelling the evolution of two contrasting accretionary systems on both sides of the proposed terrane: (1) the Palaeozoic collisional accretionary prism of the Guarguaraz Complex at the suture between the Cuyania and Chilenia microplates in western Argentina (longitude 69°W) and (2) the late Palaeozoic coastal accretionary complex within the Coastal Cordillera of central Chile (longitude 72°W). Both complexes are composed of continent-derived metasediments including up to 10-15% intercalations of disrupted oceanic crust and were subjected to high-pressure metamorphism.

According to the age spectrum of detrital zircon, the maximum sedimentation age of the metasediments of the Guarguaraz Complex is about 563 Ma (Willner et al., 2008). Their peak PT-conditions were 13-14 kbar at about 500°C (Massonne and Calderón, 2008), which represent a metamorphic geotherm of close to 10°C/km during this metamorphic stage. A decompresion path to midcrustal conditions at 8 kbar and 600°C was further derived. So far, such decompression-heating paths are only known from continent-continent collisional settings. Ages

for the peak of metamorphism (Lu/Hf system) are currently under investigation, cooling ages for the Guarguaraz Complex are at 323Ma (Ar/Ar) and 284-295Ma (zircon fission track).

In the coastal accretionary complex, accretion started before 320Ma with frontal accretion in upper levels leading to metamorphic conditions of 4-6 kbar, 250-300°C (Willner et al. 2009) after a short period of stable continental margin conditions (western margin of Chilenia). The corresponding geotherms are relatively high. Chevron folds of bedding planes and reverse faults were formed, indicative of subhorizontal shortening (Richter et al., 2007). Subhorizontal flow paths at maximum depth are proved by a near-isobaric prograde PT-path. At the same time, material more deeply transported into a subduction channel was heated against a still hot mantle at 12-14 kbar, 600-700°C and subsequently cooled at depth following an anticlockwise PT-path (Willner et al., 2004). Upwards directed forced flow is the predominant process in a subduction channel, but only little material of the subduction channel seems to have been incorporated into the accretionary prism itself.

At ~308 Ma the accretion mode changed from frontal to basal accretion leading to peak PT conditions of 7-10 kbar, 350-400°C (Willner et al., 2005). Maximum sedimentation ages and the ages of the peak of metamorphism are systematically younger in the basal accretionary prism (311 Ma and 279-308 Ma, respectively) than in the frontal accretionary systems (338-345 Ma, > 320 Ma). Deformation after accretion is characterized by pronounced flattening resulting in a penetrative subhorizontal transposition foliation by pressure solution processes (Richter et al., 2007). Static recrystallisation outlasted deformation during decompression with slight cooling. Erosion at an axial rise of the accretionary wedge balanced accretion at depth leading to recycling of material to the trench as well as filling of retrowedge basins. Accretion ended after about 100 Ma of duration (Willner et al., 2005).

The contrasting evolution of the collisional and coastal accretionary systems indicates collision of the Chilenia Terrane, presumably in Late Devonian-Early Carboniferous times, before the onset of accretion processes along the Palaeopacific coast. Chilenia formed the back-stop system of the extensive Late Palaeozoic coastal accretionary system and was first covered by sediments of a wide Late Carboniferous retrowedge basin that also received detritus from the rising collisional belt (Guarguaraz Complex) and an Early Carboniferous magmatic arc (Willner et al., 2008).

References

Massonne H-J, Calderón M (2008) P-T evolution of metapelites of the Guarguaraz Complex, Argentina - evidence for Devonian crustal thickening close to the western Gondwana margin. Rev Geol Chile 35: 215-231

Ramos VA, Jordan T, Allmendinger R, Kay S, Cortés J, Palma M (1984) Chilenia: un terreno alóctono en la evolución paleozoica de los Andes Centrales. Actas IX Congreso Geológico Argentino 2: 84-106

Richter P, Ring U, Willner AP, Leiss B (2007) Structural contacts in subduction complexes and their tectonic significance: The Late Paleozoic coastal accretionary wedge of central Chile. J Geol Soc London 164: 203-214

Willner AP, Glodny J., Gerya TV, Godoy E, Massonne H-J (2004) A counterclockwise PTt-path in high pressure-low temperature rocks from the Coastal Cordillera accretionary complex of South Central Chile: constraints for the earliest stage of subduction mass flow. Lithos 75: 283-310

Willner, A.P., Thomson, S.N., Kröner, A., Wartho, J.A., Wijbrans, J and Hervé, F. (2005). Time markers for the evolution and exhumation history of a late Palaeozoic paired metamorphic belt in central Chile (34°-35°30´S). J Pet 46, 1835-1858.

Willner AP, Gerdes A, Massonne H-J (2008) History of crustal growth and recycling at the Pacific convergent margin of South America at latitudes 29°-36°S revealed by a U-Pb and Lu-Hf isotope study of detrital zircon from late Paleozoic accretionary systems. Geochim Cosmochim Acta 253: 114-129

Willner AP, Sepúlveda FA, Hervé F, Massonne H-J, Sudo M (2009) Conditions and timing of pumpellyite-actinolite facies metamorphism in the Early Mesozoic frontal accretionary prism of the Madre de Dios Archipelago (50°20`S; S-Chile). J Petrol: in review.

Transferencia colombiana de conocimientos y experiencias de producción limpia en el beneficio de minerales auro-argentíferos

Wolff Carreño E

Proyecto Río Suratá – Convenio CDMB – BGR, erwin.wolf@cdmb.gov.co

Desde 1997 se ha venido desarrollando el Proyecto "Reducción de la Contaminación Ambiental Debida a la Pequeña Minería en la Cuenca del Río Suratá (Proyecto Río Suratá)" en el marco de la Cooperación Técnica Colombo Alemana, cuyos ejecutores han sido por Colombia la Corporación Autónoma Regional para la Defensa de la Meseta de Bucaramanga (CDMB) y por Alemania el Instituto Federal de Geociencias y Recursos Naturales (BGR) con el fin de aplicar procesos limpios y buenas prácticas ambientales sostenibles para el manejo del mercurio y del cianuro utilizado por la actividad minera auro-argentífera de pequeña escala en los municipios de Vetas y California (Departamento de Santander, Colombia).

El desarrollo de este Proyecto ha demostrado reducción de contaminación en forma económicamente sostenible, pues la recuperación del metal valioso ha sido mayor, según los datos recopilados a diciembre 31 de 2007 para las unidades productivas intervenidas en promedio: Reducción del uso de mercurio en 82%; disminución del consumo de cianuro en 36%, e incremento de productividad en 79%.

En virtud de los resultados exitosos alcanzados por este proyecto, a partir del año 2005 otras instituciones ambientales colombianas que sufren problemas de

contaminación por mercurio y cianuro derivados de la actividad minera, han solicitado de la CDMB asesoramiento, apoyo y orientación en la ejecución de proyectos encausados hacia la mitigación de los problemas ambientales generados por esta actividad. Esta transferencia de conocimientos y experiencias se ha desarrollado de la siguiente manera:

Desde el año 2005, en el Departamento de Caldas se ha trabajado con la Corporación Autónoma Regional de Caldas – CORPOCALDAS, y la gobernación de este Departamento para aunar esfuerzos interinstitucionales en gestión, orientación, capacitación y asesoramiento técnico en el tema de beneficio de minerales auroargentíferos. A la fecha el convenio no ha concluido.

En los Departamentos de Guainía y Vaupés se ejecutaron dos proyectos en los años 2006 y 2007 con el concurso de la Corporación para el Desarrollo Sostenible del Norte y el Oriente Amazónico – CDA para realizar cooperación horizontal interinstitucional en orientación, capacitación, y asesoramiento técnico-ambiental, en el tema del beneficio de minerales auríferos en el río Inírida (Departamento del Guainía), en el municipio de Taraira (Departamento del Vaupés), e igualmente capacitar a personal de la CDA para mejorar ambientalmente las fundiciones de oro en la zona urbana de Inírida (Departamento del Guainía). Sus resultados fueron: Reducción de cianuro en 85% y de mercurio en 8% para Taraira (Vaupés), y de mercurio en 71% para el río Inírida (Guainía).

Durante el año 2007 se trabajó en el departamento de Antioquia (región de Urabá) con la Corporación para el Desarrollo Sostenible del Urabá – CORPOURABÁ con el fin de aunar esfuerzos técnicos, logísticos, financieros y administrativos para prestar asesoría y apoyo en la ejecución del proyecto "Programa de producción limpia aplicado a la pequeña minería de oro en los municipios de Frontino, Cañasgordas, Abriaquí, Giraldo, Uramita, Urrao y Dabeiba, para disminuir el consumo de mercurio y cianuro", y capacitar a funcionarios de CORPOURABA en asistencia técnica, control y monitoreo en procesos de beneficio mineral. Sus resultados fueron: Reducción de cianuro en 65% y de mercurio en 97%.

En los años 2007 y 2008, en el departamento del Chocó se asesoró la ejecución de las fases 1 y 2 de un proyecto con la participación de la Corporación para el Desarrollo Sostenible del Chocó – CODECHOCÓ para apoyar la realización en Condoto (Chocó), de un diagnóstico de dos (2) operaciones de beneficio de minerales que posibilite la optimización del proceso de amalgamación llevado a cabo en dicho municipio, y para realizar las pruebas y ensayos requeridos con el fin de proponer reconversión tecnológica hacia producción más limpia, en el marco del Proyecto de CODECHOCÓ denominado "Implementación de Procesos de Producción Mas Limpia, para Reducir La Contaminación por Mercurio en el Beneficio Auro-Platinífero, como experiencia piloto en el municipio de Condoto-Departamento del Choco". Producto de este trabajo se obtuvo como resultado la reducción de mercurio en 80% para la fase 1, y del 98% en la fase 2.

En los años 2006 y 2007 se celebraron dos convenios con el Ministerio de Ambiente, Vivienda y Desarrollo Territorial – MAVDT: El primero para documentar, divulgar y socializar los resultados y experiencias exitosas de proyectos relacionadas con el manejo del mercurio en la minería de oro en Colombia con fines preventivos, cuyo resultados fueron un diagnóstico rápido del tratamiento de minerales auríferos en el departamento de Córdoba (municipio de Puerto Libertador) y la edición del libro titulado "Resultados y experiencias exitosas de proyectos relacionados con el Manejo de Mercurio en la Minería de Oro en Colombia con fines preventivos" al igual que de un video educativo acerca del manejo de mercurio llevado a cabo por la minería de oro en los departamentos de Antioquia, Nariño, Santander, y Valle del Cauca. El segundo para asistir técnicamente a por lo menos dos (2) Corporaciones Autónomas Regionales, con problemas ambientales ocasionados por el uso del mercurio en el beneficio de minerales auríferos con el fin de disminuir su consumo, cuyos resultados fueron: La elaboración de dos perfiles de proyecto de producción limpia para beneficiar minerales auríferos en los departamentos de Huila (Corporación Autónoma Regional del Alto Magdalena – CAM) y Tolima (Corporación Autónoma Regional del Tolima – CORTOLIMA), atendiendo a un diagnóstico rápido del estado actual del beneficio de minerales realizado en estos 2 departamentos con sus respectivas propuestas de diseño, y la capacitación de 11 funcionarios de 9 Autoridades Ambientales equivalente al 64% de las mismas implicadas con la temática.

Para este año 2009 se ha tramitado un convenio con la Corporación Autónoma Regional del Cauca – CRC con el fin de transferirle los conocimientos y experiencias adquiridas en el tema de tecnologías limpias para beneficiar minerales auríferos, para que ejecute el "Proyecto Piloto de Producción Más Limpia en Uso del Mercurio para la Minería de Oro".

En el desarrollo de estas tareas, la CDMB utiliza el laboratorio metalúrgico y los métodos y conceptos desarrollados con ocasión de la ejecución del Proyecto Río Suratá. En la práctica se trae una muestra de mineral desde la región colombiana objeto de la orientación, y de acuerdo con los resultados obtenidos a nivel semiindustrial y con la experticia alcanzada por el personal técnico de la CDMB en los campos de geología, mineralogía, beneficio de minerales y sus relaciones ambientales, se orientan los trabajos tecnológicos hacia la reducción del uso de mercurio y de cianuro.

Referencias

Wolf, E (2008) Incorporación de Tecnologías Limpias para Beneficiar Minerales Auríferos en la Pequeña Minería de Vetas y California (Santander) Buscando Reducir Vertimientos de Mercurio y Cianuro. Memorias XI Seminario Internacional del Medio Ambiente y Desarrollo Sostenible Cartagena (Colombia).

Pinto, E., Wolff, E, Pinzon JM, Pineda JC (2007) Resultados y experiencias exitosas de proyectos relacionados con el Manejo de Mercurio en la Minería de Oro en Colombia con fines preventivos. ISBN 978-958-97978-9-1.

Bottom topography, recent sedimentation and water balance of Cerro Prieto Dam, NE Mexico

Yutsis VV 1, Levchenko OV 2, Lowag J 3, Krivosheya K 1, de León Gómez H, Kotsarenko A 4

1 Universidad Autónoma de Nuevo León, Facultad de Ciencias de la Tierra, Linares, N.L., México. vyutsis@fct.uanl.mx

3 INNOMAR Technologie GmbH, Rostock, Germany

4 Universidad Nacional Autónoma de México, Centro de Geociencias, campus Juriquilla, Querétaro, México

Cerro Prieto Dam, a small water reservoir in the NE Mexico, is characterized by very high velocity of recent sedimentation, high sub-bottom seepage and erosion, and as a result, nonlinear water balance. These phenomenons never were studied since construction of the dam in the beginning of 1980th. So the goal of our work was to investigate the bottom topography and also sub-bottom near surface structure using the parametric acoustical effect.

High-resolution sub-bottom profiling, using the Innomar SES-2000 compact echosounder, was carried out in Cerro Prieto Dam during February-April of 2008. The survey was conducted onboard of a small motor boat. The SES transducer was mounted on the front side of the boat using light metal pipe, and all electronic equipment was installed on the deck. Accurate positioning of the boat was reached by GPS. Average speed was 8-10 km/h. Innomar's software tool ISE was provides near real-time post-processing of the collected SES data and operation procedure could be corrected on-line. Acoustic signal ensured vertical resolution of 10-15 cm at acceptable penetration up to 15 m. Bathymetry map was compiled assuming average sound velocity of 1450 m/s. The irregular bottom topography of Cerro Prieto dam was discovered. The present elevation of the water surface is about 181 m above see level, and the lake depth varies from 1-2 to 28 m.

The SES records show a distinct bottom layer of recent sediments by 0.5 – 4 m thickness which follows reservoir floor topography. Very specific acoustic anomalies, which seem to be related with gas sediments, are observed. The integrated SES, gravity, magnetic and geoelectrical data interpretation allows assuming a series of the superficial fractures focused in a NW direction, perpendicular (NE-SW) to the general deep fault zone.

Hydrological balance for the Cerro Prieto water reservoir has been analyzed for last two decades. There are three types of water level fluctuations on the Cerro Prieto dam: long-term (yearly), seasonal (sub-annual), and short-term (daily). Fluctuations in Dam water levels result from several natural factor and human influences. Analysis of this data shows nonlinearity of hydrological cycle and, as a result, uncertainty in the water balance, which may range from 2.5 up to 30-35%.

The authors would like to thank Universidad Autónoma de Nuevo León (Mexico) for funding support of the project PAICYT CT1705-07 and Innomar Technologie GmbH, who kindly provided the SES-2000 compact equipment.

The International Lateinamerika-Kolloquium, held in April 2009 at the Geosciences Centre of the Georg-August-Universität Göttingen, brings together researchers from all fields of earth sciences. The abstracts contained in this volume cover a wide range of topics on the geological evolution of the South American continent and its margins, such as processes of mountain building, uplift and erosion as well as interaction between tectonic and climatic parameters. Topics of the Lateinamerika-Kolloquium also cover landscape evolution, ecology, natural resources, geo-hazards and economic geology.



GEORG-AUGUST-UNIVERSITÄT
GÖTTINGEN

ISBN: 978-3-940344-77-9

Universitätsdrucke Göttingen